S.I.A.

REPORT

OF THE

FORTY-NINTH MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT

SHEFFIELD IN AUGUST 1879.

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ERRATA IN REPORT FOR 1878.

Page 477, line 25 from foot of page: *for* 'equally high-waters' *read* 'equally high high-waters.'
" " " 24 " " " *for* 'equally low-waters' *read* 'equally low low-waters.'
" 480, " 16 " " " *after* '1853' *insert* 'previously analysed.'
" 481, line 1 from top of page: *after* 'degrees' *insert* 'through.'
" " " 2 " " " *for* 'run through' *read* 'turn.'
" " " 12 " " " *for* '270' *read* '270°.'
" 497, " 18 " " " *for* 'on the north and' *read* 'on the north or.'
In Table of pp. 478–479, col. 1, Constituent L: *for* '29°·528' *read* '29°·533.'
" " " " " Q: *for* '13°·399' *read* '13°·394.'
" " " small type headings of cols. 4–11: *for* '1 =' *read* 'I =.'
" " " col. 7, line 16 from top: *for* '165°·3' *read* '185°·3.'
" " " small type heading of col. 10: *for* '1 = 21°·7; ν = + 12°·4' *read* 'I = 20°·1; ν = 10°·2.'

OBJECTS AND RULES

OF

THE ASSOCIATION.

OBJECTS.

The Association contemplates no interference with the ground occupied by other institutions. Its objects are:—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

Admission of Members and Associates.

All persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council, to become Life Members of the Association, Annual Subscribers, or Assocates for the year, subject to the approval of a General Meeting.

Compositions, Subscriptions, and Privileges.

Life Members shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

Annual Subscribers shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive *gratuitously* the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and*

all future years the privilege of receiving the volumes of the Association *gratis*: but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the Offices of the Association.

ASSOCIATES for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes:—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.
2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.
3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]
4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]
5. Associates for the year, subject to the payment of One Pound.
6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz.:—

1. *Gratis.*—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845, a further sum of Five Pounds.
   New Life Members who have paid Ten Pounds as a composition.
   Annual Members who have not intermitted their Annual Subscription.
2. *At reduced or Members' Prices*, viz. two-thirds of the Publication Price.—Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.
   Annual Members who have intermitted their Annual Subscription.
   Associates for the year. [Privilege confined to the volume for that year only.]
3. Members may purchase (for the purpose of completing their sets) any of the first seventeen volumes of Transactions of the Association, *and of which more than* 100 *copies remain*, at one third of the Publication Price. Application to be made at the Office of the Association, 22 Albemarle Street, London, W.

Volumes not claimed within two years of the date of publication can only be issued by direction of the Council.

Subscriptions shall be received by the Treasurer or Secretaries.

Meetings.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee two years in advance; and the arrangements for it shall be entrusted to the Officers of the Association.

General Committee.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons:—

Class A. Permanent Members.

1. Members of the Council, Presidents of the Association, and Presidents of Sections for the present and preceding years, with Authors of Reports in the Transactions of the Association.

2. Members who by the publication of Works or Papers have furthered the advancement of those subjects which are taken into consideration at the Sectional Meetings of the Association. *With a view of submitting new claims under this Rule to the decision of the Council, they must be sent to the Assistant Secretary at least one month before the Meeting of the Association. The decision of the Council on the claims of any Member of the Association to be placed on the list of the General Committee to be final.*

Class B. Temporary Members.

1. The President for the time being of any Scientific Society publishing Transactions or, in his absence, a delegate representing him; and the Secretary of such Society.[1] *Claims under this Rule to be sent to the Assistant Secretary before the opening of the Meeting.*

2. Office-bearers for the time being, or delegates, altogether not exceeding three, from Scientific Institutions established in the place of Meeting. *Claims under this Rule to be approved by the Local Secretaries before the opening of the Meeting.*

3. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing, for the Meeting of the year, by the President and General Secretaries.

4. Vice-Presidents and Secretaries of Sections.

Organizing Sectional Committees.[2]

The Presidents, Vice-Presidents, and Secretaries of the several Sections are nominated by the Council, and have power to act until their names are submitted to the General Committee for election.

From the time of their nomination they constitute Organizing Committees for the purpose of obtaining information upon the Memoirs and Reports likely to be submitted to the Sections,[3] and of preparing Reports thereon, and on the order in which it is desirable that they should be

[1] Revised by the General Committee, Sheffield, 1879.

[2] Passed by the General Committee, Edinburgh, 1871.

[3] *Notice to Contributors of Memoirs.*—Authors are reminded that, under an arrangement dating from 1871, the acceptance of Memoirs, and the days on which they are to be read, are now as far as possible determined by Organizing Committees for the several Sections *before the beginning of the Meeting.* It has therefore become necessary, in order to give an opportunity to the Committees of doing justice to the several Communications, that each Author should prepare an Abstract of his Memoir, of a length suitable for insertion in the published Transactions of the Association,

read, to be presented to the Committees of the Sections at their first meeting. The[1] Sectional Presidents of former years are *ex officio* members of the Organizing Sectional Committees.

An Organizing Committee may also hold such preliminary meetings as the President of the Committee thinks expedient, but shall, under any circumstances, meet on the first Wednesday of the Annual Meeting, at 11 A.M., to settle the terms of their Report, after which their functions as an Organizing Committee shall cease.

Constitution of the Sectional Committees.[2]

On the first day of the Annual Meeting, the President, Vice-Presidents, and Secretaries of each Section having been appointed by the General Committee, these Officers, and those previous Presidents and Vice-Presidents of the Section who may desire to attend, are to meet, at 2 P.M., in their Committee Rooms, and enlarge the Sectional Committees by selecting individuals from among the Members (not Associates) present at the Meeting whose assistance they may particularly desire. The Sectional Committees thus constituted shall have power to add to their number from day to day.

The List thus formed is to be entered daily in the Sectional Minute-Book, and a copy forwarded without delay to the Printer, who is charged with publishing the same before 8 A.M. on the next day, in the Journal of the Sectional Proceedings.

Business of the Sectional Committees.

Committee Meetings are to be held on the Wednesday at 2 P.M., on the following Thursday, Friday, Saturday, Monday, and Tuesday, from 10 to 11 A.M., punctually, for the objects stated in the Rules of the Association, and specified below.

The business is to be conducted in the following manner :—

1. The President shall call on the Secretary to read the minutes of the previous Meeting of the Committee.
2. No paper shall be read until it has been formally accepted by the Committee of the Section, and entered on the minutes accordingly.
3. Papers which have been reported on unfavourably by the Organizing Committees shall not be brought before the Sectional Committees.[3]

At the first meeting, one of the Secretaries will read the Minutes of last year's proceedings, as recorded in the Minute-Book, and the Synopsis of Recommendations adopted at the last Meeting of the Association and

and that he should send it, together with the original Memoir, by book-post, on or before....., addressed thus—"General Secretaries, British Association, 22 Albemarle Street, London, W. For Section ....." If it should be inconvenient to the Author that his paper should be read on any particular days, he is requested to send information thereof to the Secretaries in a separate note. Authors who send in their MSS. a full three weeks before the Meeting, and whose papers are accepted, will be furnished, before the Meeting, with printed copies of their Reports and Abstracts. No Report, Paper, or Abstract can be inserted in the Annual Volume unless it is handed either to the Recorder of the Section or to the Assistant Secretary, *before the conclusion of the Meeting.*

[1] Added by the General Committee, Sheffield, 1879.

[2] Passed by the General Committee, Edinburgh, 1871.

[3] These rules were adopted by the General Committee, Plymouth, 1877.

printed in the last volume of the Transactions. He will next proceed to read the Report of the Organizing Committee.[1] The list of Communications to be read on Thursday shall be then arranged, and the general distribution of business throughout the week shall be provisionally appointed. At the close of the Committee Meeting the Secretaries shall forward to the Printer a List of the Papers appointed to be read. The Printer is charged with publishing the same before 8 A.M. on Thursday in the Journal.

On the second day of the Annual Meeting, and the following days, the Secretaries are to correct, on a copy of the Journal, the list of papers which have been read on that day, to add to it a list of those appointed to be read on the next day, and to send this copy of the Journal as early in the day as possible to the Printer, who is charged with printing the same before 8 A.M. next morning in the Journal. It is necessary that one of the Secretaries of each Section (generally the Recorder) should call at the Printing Office and revise the proof each evening.

Minutes of the proceedings of every Committee are to be entered daily in the Minute-Book, which should be confirmed at the next meeting of the Committee.

Lists of the Reports and Memoirs read in the Sections are to be entered in the Minute-Book daily, which, with *all Memoirs and Copies or Abstracts of Memoirs furnished by Authors, are to be forwarded, at the close of the Sectional Meetings*, to the Assistant Secretary.

The Vice-Presidents and Secretaries of Sections become *ex officio* temporary Members of the General Committee (*vide* p. xxiii), and will receive, on application to the Treasurer in the Reception Room, Tickets entitling them to attend its Meetings.

The Committees will take into consideration any suggestions which may be offered by their Members for the advancement of Science. They are specially requested to review the recommendations adopted at preceding Meetings, as published in the volumes of the Association and the communications made to the Sections at this Meeting, for the purposes of selecting definite points of research to which individual or combined exertion may be usefully directed, and branches of knowledge on the state and progress of which Reports are wanted; to name individuals or Committees for the execution of such Reports or researches; and to state whether, and to what degree, these objects may be usefully advanced by the appropriation of the funds of the Association, by application to Government, Philosophical Institutions, or Local Authorities.

In case of appointment of Committees for special objects of Science, it is expedient that *all Members of the Committee should be named, and one of them appointed to act as Secretary, for insuring attention to business.*

Committees have power to add to their number persons whose assistance they may require.

The recommendations adopted by the Committees of Sections are to be registered in the Forms furnished to their Secretaries, and one Copy of each is to be forwarded, without delay, to the Assistant Secretary for presentation to the Committee of Recommendations. *Unless this be done, the Recommendations cannot receive the sanction of the Association.*

N.B.—Recommendations which may originate in any one of the Sections must *first be sanctioned by the Committee of that Section* before they

[1] This and the following sentence were added by the General Committee, 1871.

can be referred to the Committee of Recommendations or confirmed by the General Committee.

The [1] Committees of the Sections shall ascertain whether a Report has been made by every Committee appointed at the previous Meeting to whom a sum of money has been granted, and shall report to the Committee of Recommendations in every case where no such Report has been received.

Notices regarding Grants of Money.

Committees and individuals, to whom grants of money have been entrusted by the Association for the prosecution of particular researches in science, are required to present to each following Meeting of the Association a Report of the progress which has been made; and the Individual or the Member first named of a Committee to whom a money grant has been made must (previously to the next Meeting of the Association) forward to the General Secretaries or Treasurer a statement of the sums which have been expended, and the balance which remains disposable on each grant.

Grants of money sanctioned at any one Meeting of the Association expire *a week before* the opening of the ensuing Meeting; nor is the Treasurer authorized, after that date, to allow any claims on account of such grants, unless they be renewed in the original or a modified form by the General Committee.

No Committee shall raise money in the name or under the auspices of the British Association without special permission from the General Committee to do so; and no money so raised shall be expended except in accordance with the rules of the Association.

In each Committee, the Member first named is the only person entitled to call on the Treasurer, Professor A. W. Williamson, University College, London, W.C., for such portion of the sums granted as may from time to time be required.

In grants of money to Committees, the Association does not contemplate the payment of personal expenses to the members.

In all cases where additional grants of money are made for the continuation of Researches at the cost of the Association, the sum named is deemed to include, as a part of the amount, whatever balance may remain unpaid on the former grant for the same object.

All Instruments, Papers, Drawings, and other property of the Association are to be deposited at the Office of the Association, 22 Albemarle Street, Piccadilly, London, W., when not employed in carrying on scientific inquiries for the Association.

Business of the Sections.

The Meeting Room of each Section is opened for conversation from 10 to 11 daily. *The Section Rooms and approaches thereto can be used for no notices, exhibitions, or other purposes than those of the Association.*

At 11 precisely the Chair will be taken, and the reading of communications, in the order previously made public, commenced. At 3 P.M. the Sections will close.

Sections may, by the desire of the Committees, divide themselves into Departments, as often as the number and nature of the communications delivered in may render such divisions desirable.

[1] Passed by the General Committee at Sheffield, 1879.

A Report presented to the Association, and read to the Section which originally called for it, may be read in another Section, at the request of the Officers of that Section, with the consent of the Author.

Duties of the Doorkeepers.

1.—To remain constantly at the Doors of the Rooms to which they are appointed during the whole time for which they are engaged.

2.—To require of every person desirous of entering the Rooms the exhibition of a Member's, Associate's, or Lady's Ticket, or Reporter's Ticket, signed by the Treasurer, or a Special Ticket signed by the Assistant Secretary.

3.—Persons unprovided with any of these Tickets can only be admitted to any particular Room by order of the Secretary in that Room.

No person is exempt from these Rules, except those Officers of the Association whose names are printed in the programme, p. 1.

Duties of the Messengers.

To remain constantly at the Rooms to which they are appointed, during the whole time for which they are engaged, except when employed on messages by one of the Officers directing these Rooms.

Committee of Recommendations.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee unless previously recommended by the Committee of Recommendations.

Local Committees.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

Officers.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer shall be annually appointed by the General Committee.

Council.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

Papers and Communications.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

Accounts.

The Accounts of the Association shall be audited annually, by Auditors appointed by the General Committee.

Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., Esq., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S. L. & E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, Esq., F.R.S., Astronomer Royal, &c. John Dalton, Esq., D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
SIR T. MACDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S. L. & E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S. L. & E., &c. Sir John Robinson, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S., &c. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, Esq., M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, Esq., D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Esq., Pres. Royal Institution, Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, Esq., F.L.S., &c. Wm. Hutton, Esq., F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	The Marquis of Northampton. The Earl of Dartmouth The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. The Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, Esq., M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.
The MARQUIS OF BREADALBANE, F.R.S. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount-Edgcumbe	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c. PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir T. D. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, Esq., D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, Esq., M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, Esq., M.D. James Heywood, Esq., F.R.S.

The EARL OF ROSSE, F.R.S. ..... Cork, August 17, 1843.	The Earl of Listowel. Viscount Adare..... Sir W. R. Hamilton, Pres. R.I.A. ..... Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Kelcher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S..... York, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. ..... The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S..... Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.
SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. ..... Cambridge, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich ..... Rev. J. Graham, D.D. Rev. G. Ainslie, D.D..... G. B. Airy, Esq., M.A., D.C.L., F.R.S..... The Rev. Professor Sedgwick, M.A., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.
SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. Southampton, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L..... Lord Ashburton, D.C.L. Viscount Palmerston, M.P. ..... Right Hon. Charles Shaw Lefevre, M.P. ..... Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. ..... The Lord Bishop of Oxford, F.R.S. ..... Professor Owen, M.D., F.R.S. The Rev. Professor Powell, F.R.S....	Henry Clark, Esq., M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L. F.R.S., M.P. for the University of Oxford..... Oxford, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. ..... The Vice-Chancellor of the University ..... Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. Very Rev. the Dean of Westminster, D.D., F.R.S.... Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. H. Wentworth Acland, Esq., B.M.
The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. ..... Swansea, August 9, 1848.	The Marquis of Bute, K.T. Viscount Adare, F.R.S..... Sir H. T. De la Beche, F.R.S., Pres. G.S..... The Very Rev. the Dean of Llandaff, F.R.S..... Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S..... J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's..	Matthew Moggridge, Esq. D. Nicol, Esq., M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. Birmingham, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S. ..... The Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. ..... Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. ..... Professor Faraday, D.C.L., F.R.S..... Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.
SIR DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrews..... Edinburgh, July 21, 1850.	The Right Hon. the Lord Provost of Edinburgh ..... The Earl of Cathcart, K.C.B., F.R.S.E. ..... The Earl of Rosebery, K.T., D.C.L., F.R.S. ..... The Right Hon. David Boyle (Lord Justice-General), F.R.S.E. ..... General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E.... The Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. ..... Professor J. D. Forbes, F.R.S., Sec. R.S.E.....	Rev. Professor Kelland, M.A., F.R.S. L. & E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.E.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. — The Lord Bishop of Norwich Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. — Sir William F. F. Middleton, Bart. J. C. Cobbold, Esq., M.P. — T. B. Western, Esq.	Charles May, Esq., F.R.A.S. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq., F.L.S.
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society BELFAST, September 1, 1852.	The Earl of Enniskillen, D.C.L., F.R.S. The Earl of Rosse, Pres. R.S., M.R.I.A. Sir Henry T. De la Beche, F.R.S. Rev. Edward Hincks, D.D., M.R.I.A. Rev. P. S. Henry, D.D., Pres. Queen's College, Belfast Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S. Professor G. G. Stokes, F.R.S. — Professor Stevelly, LL.D.	W. J. C. Allen, Esq. William M'Gee, Esq., M.D. Professor W. P. Wilson.
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., Pres. Camb. Phil. Society HULL, September 7, 1853.	The Earl of Carlisle, F.R.S. — Lord Londesborough, F.R.S. Professor Faraday, D.C.L., F.R.S. — Rev. Prof. Sedgwick, M.A., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Phil. Society William Spence, Esq., F.R.S. — Lieut.-Col. Sykes, F.R.S. Professor Wheatstone, F.R.S.	Henry Cooper, Esq., M.D., V.P. Hull Lit. & Phil. Society. Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.
The EARL OF HARROWBY, F.R.S. LIVERPOOL, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge William Lassell, Esq., F.R.S. L. & E., F.R.A.S. Joseph Brooks Yates, Esq., F.S.A., F.R.G.S	Joseph Dickinson, Esq., M.D., F.R.S. Thomas Inman, Esq., M.D.
The DUKE OF ARGYLL, F.R.S., F.G.S. GLASGOW, September 12, 1855.	The Very Rev. Principal Macfarlane, D.D. Sir William Jardine, Bart., F.R.S.E. Sir Charles Lyell, M.A., LL.D., F.R.S. James Smith, Esq., F.R.S. L. & E. Walter Crum, Esq., F.R.S. Thomas Graham, Esq., M.A., F.R.S., Master of the Royal Mint Professor William Thomson, M.A., F.R.S.	John Strang, Esq., LL.D. Professor Thomas Anderson, M.D. William Gourlie, Esq.
CHARLES G. B. DAUBENY, M.D., LL.D., F.R.S., Professor of Botany in the University of Oxford CHELTENHAM, August 6, 1856.	The Earl of Ducie, F.R.S., F.G.S. The Lord Bishop of Gloucester and Bristol Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. Thomas Barwick Lloyd Baker, Esq. — The Rev. Francis Close, M.A.	Capt. Robinson, R.A. Richard Beamish, Esq., F.R.S. John West Hugell, Esq.
The REV. HUMPHREY LLOYD, D.D., D.C.L., F.R.S. L. & E., V.P.R.I.A. DUBLIN, August 26, 1857.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin The Marquis of Kildare. — Lord Talbot de Malahide The Lord Chancellor of Ireland The Lord Chief Baron, Dublin Sir William R. Hamilton, LL.D., F.R.A.S., Astronomer Royal of Ireland Lieut.-Colonel Larcom, R.E., LL.D., F.R.S. Richard Griffith, Esq., LL.D., M.R.I.A., F.R.S.E., F.G.S.	Lundy E. Foote, Esq., Rev. Professor Jellett, F.T.C.D. W. Neilson Hancock, Esq., LL.D.

RICHARD OWEN, M.D., D.C.L., V.P.R.S., F.L.S., F.G.S., Superintendent of the Natural History Departments of the British Museum. LEEDS, September 22, 1858.	The Lord Monteagle, F.R.S. The Lord Viscount Goderich, M.P., F.R.G.S. The Right Hon. M. T. Baines, M.A., M.P. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. The Rev. W. Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., Master of Trinity College, Cambridge James Garth Marshall, Esq., M.A., F.G.S. R. Monckton Milnes, Esq., D.C.L., M.P., F.R.G.S.	Rev. Thomas Hincks, B.A. W. Sykes Ward, Esq., F.C.S. Thomas Wilson, Esq., M.A.
HIS ROYAL HIGHNESS THE PRINCE CONSORT.. ABERDEEN, September 14, 1859.	The Duke of Richmond, K.G., F.R.S. The Earl of Aberdeen, LL.D., K.G., K.T., F.R.S. The Lord Provost of the City of Aberdeen Sir John F. W. Herschel, Bart., M.A., D.C.L., F.R.S. Sir David Brewster, K.H., D.C.L., F.R.S. Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. The Rev. W. V. Harcourt, M.A., F.R.S. The Rev. T. R. Robinson, D.D., F.R.S. A. Thomson, Esq., LL.D., F.R.S., Convener of the County of Aberdeen	Professor J. Nicol, F.R.S.E., F.G.S. Professor Fuller, M.A. John F. White, Esq.
The LORD WROTTESLEY, M.A., V.P.R.S., F.R.A.S. .. OXFORD, June 27, 1860.	The Earl of Derby, K.G., P.C., D.C.L., Chancellor of the Univ. of Oxford The Rev. F. Jeune, D.C.L., Vice-Chancellor of the University of Oxford The Duke of Marlborough, D.C.L., F.G.S., Lord Lieutenant of Oxfordshire The Earl of Rosse, K.P., M.A., F.R.S., F.R.A.S. The Lord Bishop of Oxford, D.D., F.R.S. The Very Rev. H. G. Liddell, D.D., Dean of Christ Church, Oxford Professor Daubeny, M.D., LL.D., F.R.S., F.L.S., F.G.S. Professor Acland, M.D., F.R.S. Professor Donkin, M.A., F.R.S., F.R.A.S.	George Rolleston, Esq., M.D., F.L.S. H. J. S. Smith, Esq., M.A., F.C.S. George Griffith, Esq., M.A., F.C.S.
WILLIAM FAIRBAIRN, Esq., LL.D., C.E., F.R.S. ..... MANCHESTER, September 4, 1861.	The Earl of Ellesmere, F.R.G.S. The Lord Stanley, M.P., D.C.L., F.R.G.S. The Lord Bishop of Manchester, D.D., F.R.S., F.G.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Sir Benjamin Heywood, Bart., F.R.S. Thomas Bazley, Esq., M.P. James Aspinall Turner, Esq., M.P. James Prescott Joule, Esq., LL.D., F.R.S., Pres. Lit. & Phil. Soc. Manchester Professor E. Hodgkinson, F.R.S., M.R.I.A., M.I.C.E. Joseph Whitworth, Esq., F.R.S., M.I.C.E.	R. D. Darbishire, Esq., B.A., F.G.S. Alfred Neild, Esq. Arthur Ransome, Esq., M.A. Professor H. E. Roscoe, B.A.
The REV. R. WILLIS, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge ..... CAMBRIDGE, October 1, 1862.	The Rev. the Vice-Chancellor of the University of Cambridge The Very Rev. Harvey Goodwin, D.D., Dean of Ely The Rev. W. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge The Rev. Professor Sedgwick, M.A., D.C.L., F.R.S. The Rev. J. Challis, M.A., F.R.S. G. B. Airy, Esq., M.A., D.C.L., F.R.S., Astronomer Royal Professor G. G. Stokes, M.A., D.C.L., Sec. R.S. Professor J. C. Adams, M.A., D.C.L., F.R.S., Pres. C.P.S.	Professor C. C. Babington, M.A., F.R.S., F.L.S. Professor G. D. Liveing, M.A. The Rev. N. M. Ferrers, M.A.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
SIR W. ARMSTRONG, C.B., LL.D., F.R.S. ..... Newcastle-on-Tyne, August 26, 1863.	Sir Walter C. Trevelyan, Bart., M.A. ..... Sir Charles Lyell, LL.D., D.C.L., F.R.S., F.G.S. ..... Hugh Taylor, Esq., Chairman of the Coal Trade ..... Isaac Lowthian Bell, Esq., Mayor of Newcastle ..... Nicholas Wood, Esq., President of the Northern Institute of Mining Engineers ..... Rev. Temple Chevallier, B.D., F.R.A.S. ..... William Fairbairn, Esq., LL.D., F.R.S.	A. Noble, Esq. Augustus H. Hunt, Esq. R. C. Clapham, Esq.
SIR CHARLES LYELL, Bart., M.A., D.C.L., F.R.S..... Bath, September 14, 1864.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somersetshire ..... The Most Noble the Marquis of Bath ..... The Right Hon. Earl Nelson ..... The Right Hon. Lord Portman ..... The Very Rev. the Dean of Hereford ..... The Venerable the Archdeacon of Bath ..... W. Tite, Esq., M.P., F.R.S., F.G.S., F.S.A. ..... A. E. Way, Esq., M.P. ..... Francis H. Dickinson, Esq. ..... W. Sanders, Esq., F.R.S., F.G.S.	C. Moore, Esq., F.G.S. C. E. Davis, Esq. The Rev. H. H. Winwood, M.A.
JOHN PHILLIPS, Esq., M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford .... Birmingham, September 6, 1865.	The Right Hon. the Earl of Lichfield, Lord-Lieutenant of Staffordshire The Right Hon. the Earl of Dudley ..... The Right Hon. Lord Leigh, Lord-Lieutenant of Warwickshire ..... The Right Hon. Lord Lyttelton, Lord-Lieutenant of Worcestershire .. The Right Hon. Lord Wrottesley, M.A., D.C.L., F.R.S., F.R.A.S. ..... The Right Rev. the Lord Bishop of Worcester ..... The Right Hon. C. B. Adderley, M.P. ..... William Scholefield, Esq., M.P. F. Osler, Esq., F.R.S. ..... J. T. Chance, Esq. The Rev. Charles Evans, M.A.....	William Mathews, jun., Esq., F.G.S. John Henry Chamberlain, Esq. The Rev. G. D. Boyle, M.A.
WILLIAM R. GROVE, Esq., Q.C., M.A., F.R.S. ..... Nottingham, August 22, 1866.	His Grace the Duke of Devonshire, Lord-Lieutenant of Derbyshire .... His Grace the Duke of Rutland, Lord-Lieutenant of Leicestershire .... The Right Hon. Lord Belper, Lord-Lieutenant of Nottinghamshire .... The Right Hon. J. E. Denison, M.P. ..... J. C. Webb, Esq., High-Sheriff of Nottinghamshire ..... Thomas Graham, Esq., F.R.S., Master of the Mint..... Joseph Hooker, Esq., M.D., F.R.S., F.L.S. ..... John Russell Hinds, Esq., F.R.S., F.R.A.S. ..... T. Close, Esq.	Dr. Robertson. Edward J. Lowe, Esq., F.R.A.S., F.L.S. The Rev. J. F. M'Callan, M.A.
HIS GRACE THE DUKE OF BUCCLEUCH, K.G., D.C.L., F.R.S..... Dundee, September 4, 1867.	The Right Hon. the Earl of Airlie, K.T..... The Right Hon. the Lord Kinnaird, K.T. ..... Sir John Ogilvy, Bart., M.P. ..... Sir Roderick I. Murchison, Bart., K.C.B., LL.D., F.R.S., F.G.S., &c..... Sir David Baxter, Bart..... Sir David Brewster, D.C.L., F.R.S., Principal of the University of Edinburgh..... James D. Forbes, Esq., LL.D., F.R.S., Principal of the United College of St. Salvator and St. Leonard, University of St. Andrews	J. Henderson, jun., Esq. John Austin Lake Gloag, Esq. Patrick Anderson, Esq.

JOSEPH DALTON HOOKER, M.D., D.C.L., F.R.S., F.L.S. NORWICH, August 19, 1868.	The Right Hon. the Earl of Leicester, Lord-Lieutenant of Norfolk Sir John Peter Boileau, Bart., F.R.S. The Rev. Adam Sedgwick, M.A., LL.D., F.R.S., F.G.S., &c., Woodwardian Professor of Geology in the University of Cambridge Sir John Lubbock, Bart., F.R.S., F.L.S., F.G.S. John Couch Adams, Esq., M.A., D.C.L., F.R.S., F.R.A.S., Lowndsean Professor of Astronomy and Geometry in the University of Cambridge Thomas Brightwell, Esq.	Dr. Donald Dalrymple. Rev. Joseph Crompton, M.A. Rev. Canon Hinds Howell.
PROFESSOR GEORGE G. STOKES, D.C.L., F.R.S. EXETER, August 18, 1869.	The Right Hon. the Earl of Devon The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., &c. Sir John Bowring, LL.D., F.R.S. William B. Carpenter, Esq., M.D., F.R.S., F.L.S. Robert Were Fox, Esq., F.R.S. W. H. Fox Talbot, Esq., M.A., LL.D., F.R.S., F.L.S.	Henry S. Ellis, Esq., F.R.A.S John C. Bowring, Esq. The Rev. R. Kirwan.
PROFESSOR T. H. HUXLEY, LL.D., F.R.S., F.G.S. LIVERPOOL, September 14, 1870.	The Right Hon. the Earl of Derby, LL.D., F.R.S. Sir Philip de Malpas Grey Egerton, Bart., M.P. The Right Hon. W. E. Gladstone, D.C.L., M.P. S. R. Graves, Esq., M.P. Sir Joseph Whitworth, Bart., LL.D., D.C.L., F.R.S. James P. Joule, Esq., LL.D., D.C.L., F.R.S. Joseph Mayer, Esq., F.S.A., F.R.G.S.	Rev. W. Banister. Reginald Harrison, Esq. Rev. Henry H. Higgins, M.A Rev. Dr. A. Hume, F.S.A.
PROFESSOR SIR WILLIAM THOMSON, M.A., LL.D., F.R.S. L. & E. EDINBURGH, August 2, 1871.	His Grace the Duke of Buccleuch, K.G., D.C.L., F.R.S. The Right Hon. the Lord Provost of Edinburgh The Right Hon. John Inglis, LL.D., Lord Justice-General of Scotland Sir Alexander Grant, Bart., M.A., Principal of the University of Edinburgh Sir Roderick I. Murchison, Bart., K.C.B., G.C.St.S., D.C.L., F.R.S. Sir Charles Lyell, Bart., D.C.L., F.R.S., F.G.S. Dr. Lyon Playfair, C.B., M.P., F.R.S. Professor Christison, M.D., D.C.L., Pres. R.S.E. Professor Balfour, F.R.S. L. & E.	Professor A. Crum Brown, M.D., F.R.S.E. J. D. Marwick, Esq., F.R.S.E.
DR W. B. CARPENTER, LL.D., F.R.S., F.L.S. BRIGHTON, August 14, 1872.	The Earl of Chichester, Lord-Lieutenant of the County of Sussex The Duke of Norfolk The Right Hon. the Duke of Richmond, K.G., P.C., D.C.L. The Right Hon. the Duke of Devonshire, K.G., D.C.L., F.G.S. Sir John Lubbock, Bart., M.P., F.R.S., F.L.S., F.G.S. Dr. Sharpey, LL.D., Sec. R.S., F.L.S. Joseph Prestwich, Esq., F.R.S., Pres. G.S.	Charles Carpenter, Esq. The Rev. Dr. Griffith. Henry Willett, Esq.
PROFESSOR ALEXANDER W. WILLIAMSON, Ph.D., F.R.S., F.C.S. BRADFORD, September 17, 1873.	The Right Hon. the Earl of Rosse, F.R.S., F.R.A.S. Lord Houghton, D.C.L., F.R.S. The Right Hon. W. E. Forster, M.P. The Mayor of Bradford. Professor Phillips, D.C.L., F.R.S. J. P. Gassiot, Esq., D.C.L., F.R.S. Sir John Hawkshaw, F.R.S., F.G.S.	The Rev. J. R. Campbell, D.D. Richard Goddard, Esq. Peile Thompson, Esq.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR J. TYNDALL, D.C.L., LL.D., F.R.S. BELFAST, August 19, 1874.	The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S. The Right Hon. the Earl of Rosse, F.R.S. Sir Richard Wallace, Bart., M.P. Rev. Dr. Henry. Dr. Andrews, F.R.S. Rev. Dr. Robinson, F.R.S. Professor Stokes, D.C.L., F.R.S.	W. Quartus Ewart, Esq. Professor G. Fuller, C.E. T. Sinclair, Esq.
SIR JOHN HAWKSHAW, C.E., F.R.S., F.G.S. BRISTOL, August 25, 1875.	The Right Hon. the Earl of Ducie, F.R.S., F.G.S. The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., F.R.S. The Mayor of Bristol Major-General Sir Henry C. Rawlinson, K.C.B., LL.D., F.R.S., F.R.G.S. Dr. W. B. Carpenter, LL.D., F.R.S., F.L.S., F.G.S. W. Sanders, Esq., F.R.S., F.G.S.	W. Lant Carpenter, Esq., B.A., B.Sc., F.C.S. John H. Clarke, Esq.
PROFESSOR THOMAS ANDREWS, M.D., LL.D., F.R.S., Hon. F.R.S.E. GLASGOW, September 6, 1876.	His Grace the Duke of Argyll, K.T., LL.D., F.R.S. L. & E., F.G.S. The Hon. the Lord Provost of Glasgow Sir William Stirling Maxwell, Bart., M.A., M.P. Sir William Thomson, M.A., LL.D., D.C.L., F.R.S. L. & E. Professor Allen Thomson, M.D., LL.D., F.R.S. L. & E. Professor A. C. Ramsay, LL.D., F.R.S., F.G.S. James Young, Esq., F.R.S., F.C.S.	Dr. W. G. Blackie, F.R.G.S. James Grahame, Esq. J. D. Marwick, Esq.
PROFESSOR ALLEN THOMSON, M.D., LL.D., F.R.S. L. & E. PLYMOUTH, August 15, 1877.	The Right Hon. the Earl of Mount-Edgcumbe The Right Hon. Lord Blachford, K.C.M.G. William Spottiswoode, Esq., M.A., LL.D., F.R.S., F.R.A.S., F.R.G.S. William Froude, Esq., M.A., C.E., F.R.S. Charles Spence Bate, Esq., F.R.S., F.L.S.	William Adams, Esq. William Square, Esq. Hamilton Whiteford, Esq.
WILLIAM SPOTTISWOODE, Esq., M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S. DUBLIN, August 14, 1878.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin His Grace the Duke of Abercorn, K.G. The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S., F.G.S. The Right Hon. the Earl of Rosse, B.A., D.C.L., F.R.S., F.R.A.S., M.R.I.A. The Right Hon. Lord O'Hagan, M.R.I.A. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S.	Professor R. S. Ball, M.A., F.R.S. James Goff, Esq. John Norwood, Esq., LL.D. Professor G. Sigerson, M.D.
PROFESSOR G. J. ALLMAN, M.D., LL.D., F.R.S. L. & E., M.R.I.A., Pres. L.S. SHEFFIELD, August 20, 1879.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Hon. the Earl of Wharncliffe, F.R.G.S. W. H. Brittain, Esq. (Master Cutler) Professor T. H. Huxley, Ph.D., LL.D., Sec. R.S., F.L.S., F.G.S. Professor W. Odling, M.B., F.R.S., F.C.S.	H. Clifton Sorby, Esq., F.R.S., F.G.S. J. F. Moss, Esq.

Presidents and Secretaries of the Sections of the Association.

Date and Place	Presidents	Secretaries
MATHEMATICAL AND PHYSICAL SCIENCES.		
COMMITTEE OF SCIENCES, I.—MATHEMATICS AND GENERAL PHYSICS.		
1832. Oxford.....	Davies Gilbert, D.C.L., F.R.S.	Rev. H. Coddington.
1833. Cambridge	Sir D. Brewster, F.R.S.	Prof. Forbes.
1834. Edinburgh	Rev. W. Whewell, F.R.S.	Prof. Forbes, Prof. Lloyd.
SECTION A.—MATHEMATICS AND PHYSICS.		
1835. Dublin.....	Rev. Dr. Robinson	Prof. Sir W. R. Hamilton, Prof. Wheatstone.
1836. Bristol.....	Rev. William Whewell, F.R.S.	Prof. Forbes, W. S. Harris, F. W. Jerrard.
1837. Liverpool...	Sir D. Brewster, F.R.S.	W. S. Harris, Rev. Prof. Powell, Prof. Stevelly.
1838. Newcastle	Sir J. F. W. Herschel, Bart., F.R.S.	Rev. Prof. Chevallier, Major Sabine, Prof. Stevelly.
1839. Birmingham	Rev. Prof. Whewell, F.R.S....	J. D. Chance, W. Snow Harris, Prof. Stevelly.
1840. Glasgow ...	Prof. Forbes, F.R.S.....	Rev. Dr. Forbes, Prof. Stevelly, Arch. Smith.
1841. Plymouth	Rev. Prof. Lloyd, F.R.S.	Prof. Stevelly.
1842. Manchester	Very Rev. G. Peacock, D.D., F.R.S.	Prof. M'Culloch, Prof. Stevelly, Rev. W. Scoresby.
1843. Cork.....	Prof. M'Culloch, M.R.I.A. ...	J. Nott, Prof. Stevelly.
1844. York.....	The Earl of Rosse, F.R.S. ...	Rev. Wm. Hey, Prof. Stevelly.
1845. Cambridge	The Very Rev. the Dean of Ely.	Rev. H. Goodwin, Prof. Stevelly, G. G. Stokes.
1846. Southampton.	Sir John F. W. Herschel, Bart., F.R.S.	John Drew, Dr. Stevelly, G. G. Stokes.
1847. Oxford.....	Rev. Prof. Powell, M.A., F.R.S.	Rev. H. Price, Prof. Stevelly, G. G. Stokes.
1848. Swansea ...	Lord Wrottesley, F.R.S.	Dr. Stevelly, G. G. Stokes.
1849. Birmingham	William Hopkins, F.R.S.....	Prof. Stevelly, G. G. Stokes, W. Ridout Wills.
1850. Edinburgh	Prof. J. D. Forbes, F.R.S., Sec. R.S.E.	W. J. Macquorn Rankine, Prof. Smyth, Prof. Stevelly, Prof. G. G. Stokes.
1851. Ipswich ...	Rev. W. Whewell, D.D., F.R.S., &c.	S. Jackson, W. J. Macquorn Rankine, Prof. Stevelly, Prof. G. G. Stokes.
1852. Belfast.....	Prof. W. Thomson, M.A., F.R.S. L. & E.	Prof. Dixon, W. J. Macquorn Rankine, Prof. Stevelly, J. Tyndall.
1853. Hull.....	The Very Rev. the Dean of Ely, F.R.S.	B. Blaydes Haworth, J. D. Sollitt, Prof. Stevelly, J. Welsh.
1854. Liverpool...	Prof. G. G. Stokes, M.A., Sec. R.S.	J. Hartnup, H. G. Puckle, Prof. Stevelly, J. Tyndall, J. Welsh.
1855. Glasgow ...	Rev. Prof. Kelland, M.A., F.R.S. L. & E.	Rev. Dr. Forbes, Prof. D. Gray, Prof. Tyndall.
1856. Cheltenham	Rev. R. Walker, M.A., F.R.S.	C. Brooke, Rev. T. A. Southwood, Prof. Stevelly, Rev. J. C. Turnbull.
1857. Dublin.....	Rev. T. R. Robinson, D.D., F.R.S., M.R.I.A.	Prof. Curtis, Prof. Hennessy, P. A. Ninnis, W. J. Macquorn Rankine, Prof. Stevelly.
1858. Leeds	Rev. W. Whewell, D.D., V.P.R.S.	Rev. S. Earnshaw, J. P. Hennessy, Prof. Stevelly, H. J. S. Smith, Prof. Tyndall.

Date and Place	Presidents	Secretaries
1859. Aberdeen...	The Earl of Rosse, M.A., K.P., F.R.S.	J. P. Hennessy, Prof. Maxwell, H. J. S. Smith, Prof. Stevelly.
1860. Oxford.....	Rev. B. Price, M.A., F.R.S....	Rev. G C. Bell, Rev. T. Rennison, Prof. Stevelly.
1861. Manchester	G. B. Airy, M.A., D.C.L., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1862. Cambridge	Prof. G. G. Stokes, M.A., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1863. Newcastle	Prof. W. J. Macquorn Rankine C.E., F.R.S.	Rev. N. Ferrers, Prof. Fuller, F. Jenkin, Prof. Stevelly, Rev. C. T. Whitley.
1864. Bath.....	Prof. Cayley, M.A., F.R.S., F.R.A.S.	Prof. Fuller, F. Jenkin, Rev. G. Buckle, Prof. Stevelly.
1865. Birmingham	W. Spottiswoode, M.A., F.R.S. F.R.A.S.	Rev. T. N. Hutchinson, F. Jenkin, G. S. Mathews, Prof. H. J. S. Smith, J. M. Wilson.
1866. Nottingham	Prof. Wheatstone, D.C.L., F.R.S.	Fleeming Jenkin, Prof. H. J. S. Smith, Rev. S. N. Swann.
1867. Dundee ...	Prof. Sir W. Thomson, D.C.L., F.R.S.	Rev. G. Buckle, Prof. G. C. Foster, Prof. Fuller, Prof. Swan.
1868. Norwich ...	Prof. J. Tyndall, LL.D., F.R.S.	Prof. G. C. Foster, Rev. R. Harley, R. B. Hayward.
1869. Exeter.....	Prof. J. J. Sylvester, LL.D., F.R.S.	Prof. G. C. Foster, R. B. Hayward, W. K. Clifford.
1870. Liverpool...	J. Clerk Maxwell, M.A., LL.D., F.R.S.	Prof. W. G. Adams, W. K. Clifford, Prof. G. C. Foster, Rev. W. Allen Whitworth.
1871. Edinburgh	Prof. P. G. Tait, F.R.S.E. ...	Prof. W. G. Adams, J. T. Bottomley, Prof. W. K. Clifford, Prof. J. D. Everett, Rev. R. Harley.
1872. Brighton ...	W. De La Rue, D.C.L., F.R.S.	Prof. W. K. Clifford, J. W. L. Glaisher, Prof. A. S. Herschel, G. F. Rodwell.
1873. Bradford ...	Prof. H. J. S. Smith, F.R.S.	Prof. W. K. Clifford, Prof. Forbes, J. W. L. Glaisher, Prof. A. S. Herschel.
1874. Belfast.....	Rev. Prof. J. H. Jellett, M.A., M.R.I.A.	J. W. L. Glaisher, Prof. Herschel, Randal Nixon, J. Perry, G. F. Rodwell.
1875. Bristol.....	Prof. Balfour Stewart, M.A., LL.D., F.R.S.	Prof. W. F. Barrett, J. W. L. Glaisher, C. T. Hudson, G. F. Rodwell.
1876. Glasgow ...	Prof. Sir W. Thomson, M.A., D.C.L., F.R.S.	Prof. W. F. Barrett, J. T. Bottomley, Prof. G. Forbes, J. W. L. Glaisher, T. Muir.
1877. Plymouth...	Prof. G. C. Foster, B.A., F.R.S., Pres. Physical Soc.	Prof. W. F. Barrett, J. T. Bottomley, J. W. L. Glaisher, F. G. Landon.
1878. Dublin.....	Rev. Prof. Salmon, D.D., D.C.L., F.R.S.	Prof. J. Casey, G. F. Fitzgerald, J. W. L. Glaisher, Dr. O. J. Lodge.
1879. Sheffield ...	George Johnstone Stoney, M.A., F.R.S.	A. H. Allen, J. W. L. Glaisher, Dr. O. J. Lodge, D. McAlister.

CHEMICAL SCIENCE.

COMMITTEE OF SCIENCES, II.—CHEMISTRY, MINERALOGY.

1832. Oxford.....	John Dalton, D.C.L., F.R.S.	James F. W. Johnston.
1833. Cambridge	John Dalton, D.C.L., F.R.S.	Prof. Miller.
1834. Edinburgh	Dr. Hope	Mr. Johnston, Dr. Christison.

SECTION B.—CHEMISTRY AND MINERALOGY.

Date and Place	Presidents	Secretaries
1835. Dublin.....	Dr. T. Thomson, F.R.S.	Dr. Apjohn, Prof. Johnston.
1836. Bristol.....	Rev. Prof. Cumming	Dr. Apjohn, Dr. C. Henry, W. Herapath.
1837. Liverpool...	Michael Faraday, F.R.S.....	Prof. Johnston, Prof. Miller, Dr. Reynolds.
1838. Newcastle	Rev. William Whewell, F.R.S.	Prof. Miller, H. L. Pattinson, Thomas Richardson.
1839. Birmingham	Prof. T. Graham, F.R.S.	Dr. Golding Bird, Dr. J. B. Melson.
1840. Glasgow ...	Dr. Thomas Thomson, F.R.S.	Dr. R. D. Thomson, Dr. T. Clark, Dr. L. Playfair.
1841. Plymouth...	Dr. Daubeny, F.R.S.	J. Prideaux, Robert Hunt, W. M. Tweedy.
1842. Manchester	John Dalton, D.C.L., F.R.S.	Dr. L. Playfair, R. Hunt, J. Graham.
1843. Cork.....	Prof. Apjohn, M.R.I.A.....	R. Hunt, Dr. Sweeny.
1844. York.....	Prof. T. Graham, F.R.S.	Dr. L. Playfair, E. Solly, T. H. Barker.
1845. Cambridge	Rev. Prof. Cumming	R. Hunt, J. P. Joule, Prof. Miller, E. Solly.
1846. Southampton	Michael Faraday, D.C.L., F.R.S.	Dr. Miller, R. Hunt, W. Randall.
1847. Oxford.....	Rev. W. V. Harcourt, M.A., F.R.S.	B. C. Brodie, R. Hunt, Prof. Solly.
1848. Swansea ...	Richard Phillips, F.R.S.	T. H. Henry, R. Hunt, T. Williams.
1849. Birmingham	John Percy, M.D., F.R.S.....	R. Hunt, G. Shaw.
1850. Edinburgh	Dr. Christison, V.P.R.S.E.	Dr. Anderson, R. Hunt, Dr. Wilson.
1851. Ipswich ...	Prof. Thomas Graham, F.R.S.	T. J. Pearsall, W. S. Ward.
1852. Belfast.....	Thomas Andrews, M.D., F.R.S.	Dr. Gladstone, Prof. Hodges, Prof. Ronalds.
1853. Hull	Prof. J. F. W. Johnston, M.A., F.R.S.	H. S. Blundell, Prof. R. Hunt, T. J. Pearsall.
1854. Liverpool	Prof. W. A. Miller, M.D., F.R.S.	Dr. Edwards, Dr. Gladstone, Dr. Price.
1855. Glasgow ...	Dr. Lyon Playfair, C.B., F.R.S.	Prof. Frankland, Dr. H. E. Roscoe.
1856. Cheltenham	Prof. B. C. Brodie, F.R.S. ...	J. Horsley, P. J. Worsley, Prof. Voelcker.
1857. Dublin.....	Prof. Apjohn, M.D., F.R.S., M.R.I.A.	Dr. Davy, Dr. Gladstone, Prof. Sullivan.
1858. Leeds	Sir J. F. W. Herschel, Bart., D.C.L.	Dr. Gladstone, W. Odling, R. Reynolds.
1859. Aberdeen...	Dr. Lyon Playfair, C.B., F.R.S.	J. S. Brazier, Dr. Gladstone, G. D. Liveing, Dr. Odling.
1860. Oxford.....	Prof. B. C. Brodie, F.R.S.....	A. Vernon Harcourt, G. D. Liveing, A. B. Northcote.
1861. Manchester	Prof. W. A. Miller, M.D., F.R.S.	A. Vernon Harcourt, G. D. Liveing.
1862. Cambridge	Prof. W. A. Miller, M.D., F.R.S.	H. W. Elphinstone, W. Odling, Prof. Roscoe.
1863. Newcastle	Dr. Alex. W. Williamson, F.R.S.	Prof. Liveing, H. L. Pattinson, J. C. Stevenson.
1864. Bath.....	W. Odling, M.B., F.R.S., F.C.S.	A. V. Harcourt, Prof. Liveing, R. Biggs.
1865. Birmingham	Prof. W. A. Miller, M.D., V.P.R.S.	A. V. Harcourt, H. Adkins, Prof. Wanklyn, A. Winkler Wills.
1866. Nottingham	H. Bence Jones, M.D., F.R.S.	J. H. Atherton, Prof. Liveing, W. J. Russell, J. White.
1867. Dundee ...	Prof. T. Anderson, M.D., F.R.S.E.	A. Crum Brown, Prof. G. D. Liveing, W. J. Russell.
1868. Norwich ...	Prof. E. Frankland, F.R.S., F.C.S.	Dr. A. Crum Brown, Dr. W. J. Russell, F. Sutton.
1869. Exeter	Dr. H. Debus, F.R.S., F.C.S.	Prof. A. Crum Brown, Dr. W. J. Russell, Dr. Atkinson.

Date and Place	Presidents	Secretaries
1870. Liverpool...	Prof. H. E. Roscoe, B.A., F.R.S., F.C.S.	Prof. A. Crum Brown, A. E. Fletcher, Dr. W. J. Russell.
1871. Edinburgh	Prof. T. Andrews, M.D., F.R.S.	J. T. Buchanan, W. N. Hartley, T. E. Thorpe.
1872. Brighton ...	Dr. J. H. Gladstone, F.R.S....	Dr. Mills, W. Chandler Roberts, Dr. W. J. Russell, Dr. T. Wood.
1873. Bradford ...	Prof. W. J. Russell, F.R.S....	Dr. Armstrong, Dr. Mills, W. Chandler Roberts, Dr. Thorpe.
1874. Belfast.....	Prof. A. Crum Brown, M.D., F.R.S.E., F.C.S.	Dr. T. Cranstoun Charles, W. Chandler Roberts, Prof. Thorpe.
1875. Bristol.....	A. G. Vernon Harcourt, M.A., F.R.S., F.C.S.	Dr. H. E. Armstrong, W. Chandler Roberts, W. A. Tilden.
1876. Glasgow ...	W. H. Perkin, F.R.S.	W. Dittmar, W. Chandler Roberts, J. M. Thomson, W. A. Tilden.
1877. Plymouth...	F. A. Abel, F.R.S., F.C.S. ...	Dr. Oxland, W. Chandler Roberts, J. M. Thomson.
1878. Dublin.....	Prof. Maxwell Simpson, M.D., F.R.S., F.C.S.	W. Chandler Roberts, J. M. Thomson, Dr. C. R. Tichborne, T. Wills.
1879. Sheffield ...	Prof. Dewar, M.A., F.R.S.	H. S. Bell, W. Chandler Roberts, J. M. Thomson.

GEOLOGICAL (AND, UNTIL 1851, GEOGRAPHICAL) SCIENCE.

COMMITTEE OF SCIENCES, III.—GEOLOGY AND GEOGRAPHY.

1832. Oxford.....	R. I. Murchison, F.R.S.	John Taylor.
1833. Cambridge.	G. B. Greenough, F.R.S.	W. Lonsdale, John Phillips.
1834. Edinburgh.	Prof. Jameson	Prof. Phillips, T. Jameson Torrie, Rev. J. Yates.

SECTION C.—GEOLOGY AND GEOGRAPHY.

1835. Dublin.....	R. J. Griffith	Captain Portlock, T. J. Torrie.
1836. Bristol.....	Rev. Dr. Buckland, F.R.S.—*Geography*, R. I. Murchison, F.R.S.	William Sanders, S. Stutchbury, T. J. Torrie.
1837. Liverpool...	Rev. Prof. Sedgwick, F.R.S.—*Geography*, G.B.Greenough, F.R.S.	Captain Portlock, R. Hunter.—*Geography*, Captain H. M. Denham, R.N.
1838. Newcastle...	C. Lyell, F.R.S., V.P.G.S.—*Geography*, Lord Prudhope.	W. C. Trevelyan, Capt. Portlock.—*Geography*, Capt. Washington.
1839. Birmingham	Rev. Dr. Buckland, F.R.S.—*Geography*, G.B.Greenough, F.R.S.	George Lloyd, M.D., H. E. Strickland, Charles Darwin.
1840. Glasgow ...	Charles Lyell, F.R.S.—*Geography*, G. B. Greenough, F.R.S.	W. J. Hamilton, D. Milne, Hugh Murray, H. E. Strickland, John Scoular, M.D.
1841. Plymouth...	H. T. De la Beche, F.R.S. ...	W. J. Hamilton, Edward Moore, M.D., R. Hutton.
1842. Manchester	R. I. Murchison, F.R.S.	E. W. Binney, R. Hutton, Dr. R. Lloyd, H. E. Strickland.
1843. Cork.....	Richard E. Griffith, F.R.S., M.R.I.A.	Francis M. Jennings, H. E. Strickland.
1844. York.....	Henry Warburton, M.P., Pres. Geol. Soc.	Prof. Ansted, E. H. Bunbury.
1845. Cambridge.	Rev. Prof. Sedgwick, M.A., F.R.S.	Rev. J. C. Cumming, A. C. Ramsay, Rev. W. Thorp.
1846. Southampton	Leonard Horner, F.R.S.—*Geography*, G. B. Greenough, F.R.S.	Robert A. Austen, Dr. J. H. Norten, Prof. Oldham.—*Geography*, Dr. C. T. Beke.

Date and Place	Presidents	Secretaries
1847. Oxford.....	Very Rev. Dr. Buckland, F.R.S.	Prof. Ansted, Prof. Oldham, A. C. Ramsay, J. Ruskin.
1848. Swansea ...	Sir H. T. De la Beche, C.B., F.R.S.	Starling Benson, Prof. Oldham, Prof. Ramsay.
1849. Birmingham	Sir Charles Lyell, F.R.S., F.G.S.	J. Beete Jukes, Prof. Oldham, Prof. A. C. Ramsay.
1850. Edinburgh[1]	Sir Roderick I. Murchison, F.R.S.	A. Keith Johnston, Hugh Miller, Prof. Nicol.

SECTION C (*continued*).—GEOLOGY.

1851. Ipswich ...	William Hopkins, M.A., F.R.S.	C. J. F. Bunbury, G. W. Ormerod, Searles Wood.
1852. Belfast.....	Lieut.-Col. Portlock, R.E., F.R.S.	James Bryce, James MacAdam, Prof. M'Coy, Prof. Nicol.
1853. Hull	Prof. Sedgwick, F.R.S.....	Prof. Harkness, William Lawton.
1854. Liverpool..	Prof. Edward Forbes, F.R.S.	John Cunningham, Prof. Harkness, G. W. Ormerod, J. W. Woodall.
1855. Glasgow ...	Sir R. I. Murchison, F.R.S....	James Bryce, Prof. Harkness, Prof. Nicol.
1856. Cheltenham	Prof. A. C. Ramsay, F.R.S....	Rev. P. B. Brodie, Rev. R. Hepworth, Edward Hull, J. Scougall, T. Wright.
1857. Dublin	The Lord Talbot de Malahide	Prof. Harkness, Gilbert Sanders, Robert H. Scott.
1858. Leeds	William Hopkins, M.A., LL.D., F.R.S.	Prof. Nicol, H. C. Sorby, E. W. Shaw.
1859. Aberdeen...	Sir Charles Lyell, LL. D., D.C.L., F.R.S.	Prof. Harkness, Rev. J. Longmuir, H. C. Sorby.
1860. Oxford	Rev. Prof. Sedgwick, LL.D., F.R.S., F.G.S.	Prof. Harkness, Edward Hull, Capt. D. C. L. Woodall.
1861. Manchester	Sir R. I. Murchison, D.C.L., LL.D., F.R.S.	Prof. Harkness, Edward Hull, T. Rupert Jones, G. W. Ormerod.
1862. Cambridge	J. Beete Jukes, M.A., F.R.S.	Lucas Barrett, Prof. T. Rupert Jones, H. C. Sorby.
1863. Newcastle	Prof. Warington W. Smyth, F.R.S., F.G.S.	E. F. Boyd, John Daglish, H. C. Sorby, Thomas Sopwith.
1864. Bath.....	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	W. B. Dawkins, J. Johnston, H. C. Sorby, W. Pengelly.
1865. Birmingham	Sir R. I. Murchison, Bart., K.C.B.	Rev. P. B. Brodie, J. Jones, Rev. E. Myers, H. C. Sorby, W. Pengelly.
1866. Nottingham	Prof. A. C. Ramsay, LL.D., F.R.S.	R. Etheridge, W. Pengelly, T. Wilson, G. H. Wright.
1867. Dundee ...	Archibald Geikie, F.R.S., F.G.S.	Edward Hull, W. Pengelly, Henry Woodward.
1868. Norwich ...	R. A. C. Godwin-Austen, F.R.S., F.G.S.	Rev. O. Fisher, Rev. J. Gunn, W. Pengelly, Rev. H. H. Winwood.
1869. Exeter	Prof. R. Harkness, F.R.S., F.G.S.	W. Pengelly, W. Boyd Dawkins, Rev. H. H. Winwood.
1870. Liverpool...	Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S.	W. Pengelly, Rev. H. H. Winwood, W. Boyd Dawkins, G. H. Morton.
1871. Edinburgh	Prof. A. Geikie, F.R.S., F.G.S.	R. Etheridge, J. Geikie, J. McKenny Hughes, L. C. Miall.

[1] At a meeting of the General Committee held in 1850, it was resolved "That the subject of Geography be separated from Geology and combined with Ethnology, to constitute a separate Section, under the title of the 'Geographical and Ethnological Section,'" for Presidents and Secretaries of which see page xliii.

Date and Place	Presidents	Secretaries
1872. Brighton ...	R. A. C. Godwin-Austen, F.R.S.	L. C. Miall, George Scott, William Topley, Henry Woodward.
1873. Bradford ...	Prof. J. Phillips, D.C.L., F.R.S., F.G.S.	L. C. Miall, R. H. Tiddeman, W. Topley.
1874. Belfast.....	Prof. Hull. M.A., F.R.S., F.G.S.	F. Drew, L. C. Miall, R. G. Symes, R. H. Tiddeman.
1875. Bristol.....	Dr. Thomas Wright, F.R.S.E., F.G.S.	L. C. Miall, E. B. Tawney, W. Topley.
1876. Glasgow ...	Prof. John Young, M.D.	J. Armstrong, F. W. Rudler, W. Topley.
1877. Plymouth...	W. Pengelly, F.R.S.....	Dr. Le Neve Foster, R. H. Tiddeman, W. Topley.
1878. Dublin.....	John Evans, D.C.L., F.R.S., F.S.A., F.G.S.	E. T. Hardman, Prof. J. O'Reilly, R. H. Tiddeman.
1879. Sheffield ...	Prof. P. Martin Duncar, M.B., F.R.S., F.G.S.	W. Topley, G. Blake Walker.

BIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, IV.—ZOOLOGY, BOTANY, PHYSIOLOGY, ANATOMY.

1832. Oxford.....	Rev. P. B. Duncan, F.G.S. ...	Rev. Prof. J. S. Henslow.
1833. Cambridge[1]	Rev. W. L. P. Garnons, F.L.S.	C. C. Babington, D. Don.
1834. Edinburgh.	Prof. Graham.....	W. Yarrell, Prof. Burnett.

SECTION D.—ZOOLOGY AND BOTANY.

1835. Dublin.....	Dr. Allman...	J. Curtis, Dr. Litton.
1836. Bristol.....	Rev. Prof. Henslow	J. Curtis, Prof. Don, Dr. Riley, S. Rootsey.
1837. Liverpool...	W. S. MacLeay.....	C. C. Babington, Rev. L. Jenyns, W. Swainson.
1838. Newcastle	Sir W. Jardine, Bart.	J. E. Gray, Prof. Jones, R. Owen, Dr. Richardson.
1839. Birmingham	Prof. Owen, F.R.S.	E. Forbes, W. Ick, R. Patterson.
1840. Glasgow ...	Sir W. J. Hooker, LL.D.....	Prof. W. Couper, E. Forbes, R. Patterson.
1841. Plymouth...	John Richardson, M.D., F.R.S.	J. Couch, Dr. Lankester, R. Patterson.
1842. Manchester	Hon. and Very Rev. W. Herbert, LL.D., F.L.S.	Dr. Lankester, R. Patterson, J. A. Turner.
1843. Cork.....	William Thompson, F.L.S. ...	G. J. Allman, Dr. Lankester, R. Patterson.
1844. York.....	Very Rev. the Dean of Manchester.	Prof. Allman, H. Goodsir, Dr. King, Dr. Lankester.
1845. Cambridge	Rev. Prof. Henslow, F.L.S....	Dr. Lankester, T. V. Wollaston.
1846. Southampton	Sir J. Richardson, M.D., F.R.S.	Dr. Lankester, T. V. Wollaston, H. Wooldridge.
1847. Oxford.....	H. E. Strickland, M.A., F.R.S.	Dr. Lankester, Dr. Melville, T. V. Wollaston.

SECTION D (*continued*).—ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

[For the Presidents and Secretaries of the Anatomical and Physiological Subsections and the temporary Section E of Anatomy and Medicine, see p. xlii.]

1848. Swansea ...	L. W. Dillwyn, F.R.S.....	Dr. R. Wilbraham Falconer, A. Henfrey, Dr. Lankester.
1849. Birmingham	William Spence, F.R.S.	Dr. Lankester, Dr. Russell.

[1] At this Meeting Physiology and Anatomy were made a separate Committee, for Presidents and Secretaries of which see p. xlii.

Date and Place	Presidents	Secretaries
1850. Edinburgh	Prof. Goodsir, F.R.S. L. & E.	Prof. J. H. Bennett, M.D., Dr. Lankester, Dr. Douglas Maclagan.
1851. Ipswich ...	Rev. Prof. Henslow, M.A., F.R.S.	Prof. Allman, F. W. Johnston, Dr. E. Lankester.
1852. Belfast.....	W. Ogilby	Dr. Dickie, George C. Hyndman, Dr. Edwin Lankester.
1853. Hull.....	C. C. Babington, M.A., F.R.S.	Robert Harrison, Dr. E. Lankester.
1854. Liverpool...	Prof. Balfour, M.D., F.R.S....	Isaac Byerley, Dr. E. Lankester.
1855. Glasgow ...	Rev. Dr. Fleeming, F.R.S.E.	William Keddie, Dr. Lankester.
1856. Cheltenham	Thomas Bell, F.R.S., Pres.L.S.	Dr. J. Abercrombie, Prof. Buckman, Dr. Lankester.
1857. Dublin.....	Prof. W. H. Harvey, M.D., F.R.S.	Prof. J. R. Kinahan, Dr. E. Lankester, Robert Patterson, Dr. W. E. Steele.
1858. Leeds	C. C. Babington, M.A., F.R.S.	Henry Denny, Dr. Heaton, Dr. E. Lankester, Dr. E. Perceval Wright.
1859. Aberdeen...	Sir W. Jardine, Bart., F.R.S.E.	Prof. Dickie, M.D., Dr. E. Lankester, Dr. Ogilvy.
1860. Oxford.....	Rev. Prof. Henslow, F.L.S....	W. S. Church, Dr. E. Lankester, P. L. Sclater, Dr. E. Perceval Wright.
1861. Manchester	Prof. C. C. Babington, F.R.S.	Dr. T. Alcock, Dr. E. Lankester, Dr. P. L. Sclater, Dr. E. P. Wright.
1862. Cambridge	Prof. Huxley, F.R.S.	Alfred Newton, Dr. E. P. Wright.
1863. Newcastle	Prof. Balfour, M.D., F.R.S....	Dr. E. Charlton, A. Newton, Rev. H. B. Tristram, Dr. E. P. Wright.
1864. Bath.....	Dr. John E. Gray, F.R.S. ...	H. B. Brady, C. E. Broom, H. T. Stainton, Dr. E. P. Wright.
1865. Birmingham	T. Thomson, M.D., F.R.S. ...	Dr. J. Anthony, Rev. C. Clarke, Rev. H. B. Tristram, Dr. E. P. Wright.

SECTION D (*continued*).—BIOLOGY.[1]

1866. Nottingham	Prof. Huxley, LL.D., F.R.S. —*Physiological Dep.*, Prof. Humphry, M.D., F.R.S.—*Anthropological Dep.*, Alf. R. Wallace, F.R.G.S.	Dr. J. Beddard, W. Felkin, Rev. H. B. Tristram, W. Turner, E. B. Tylor, Dr. E. P. Wright.
1867. Dundee ...	Prof. Sharpey, M.D., Sec. R.S. —*Dep. of Zool. and Bot.*, George Busk, M.D., F.R.S.	C. Spence Bate, Dr. S. Cobbold, Dr. M. Foster, H. T. Stainton, Rev. H. B. Tristram, Prof. W. Turner.
1868. Norwich ...	Rev. M. J. Berkeley, F.L.S. —*Dep. of Physiology*, W. H. Flower, F.R.S.	Dr. T. S. Cobbold, G. W. Firth, Dr. M. Foster, Prof. Lawson, H. T. Stainton, Rev. Dr. H. B. Tristram, Dr. E. P. Wright.
1869. Exeter.....	George Busk, F.R.S., F.L.S. —*Dep. of Bot. and Zool.*, C. Spence Bate, F.R.S.—*Dep. of Ethno.*, E. B. Tylor.	Dr. T. S. Cobbold, Prof. M. Foster, E. Ray Lankester, Prof. Lawson, H. T Stainton, Rev. H. B. Tristram.
1870. Liverpool...	Prof. G. Rolleston, M.A., M.D., F.R.S., F.L.S.—*Dep. of Anat. and Physiol.*, Prof. M. Foster, M.D., F.L.S.—*Dep. of Ethno.*, J. Evans, F.R.S.	Dr. T. S. Cobbold, Sebastian Evans, Prof. Lawson, Thos. J. Moore, H. T. Stainton, Rev. H. B. Tristram, C. Staniland Wake, E. Ray Lankester.
1871. Edinburgh	Prof. Allen Thomson, M.D., F.R.S.—*Dep. of Bot. and Zool.*, Prof. Wyville Thomson, F.R.S.—*Dep. of Anthropol.*, Prof. W. Turner, M.D.	Dr. T. R. Fraser, Dr. Arthur Gamgee, E. Ray Lankester, Prof. Lawson, H. T. Stainton, C. Staniland Wake, Dr. W. Rutherford, Dr. Kelburne King.

[1] At a meeting of the General Committee in 1865, it was resolved:—"That the title of Section D be changed to Biology;" and "That for the word 'Subsection,' in the rules for conducting the business of the Sections, the word 'Department' be substituted."

Date and Place	Presidents	Secretaries
1872. Brighton ...	Sir J. Lubbock, Bart., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. Burdon Sanderson, F.R.S.—*Dep. of Anthropol.*, Col. A. Lane Fox, F.G.S.	Prof. Thiselton-Dyer, H. T. Stainton, Prof. Lawson, F. W. Rudler, J. H. Lamprey, Dr. Gamgee, E. Ray Lankester, Dr. Pye-Smith.
1873. Bradford ...	Prof. Allman, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Rutherford, M.D.—*Dep. of Anthropol.*, Dr. Beddoe, F.R.S.	Prof. Thiselton-Dyer, Prof. Lawson, R. M'Lachlan, Dr. Pye-Smith, E. Ray Lankester, F. W. Rudler, J. H. Lamprey.
1874. Belfast	Prof. Redfern, M.D.—*Dep. of Zool. and Bot.*, Dr. Hooker, C.B., Pres. R.S.—*Dep. of Anthrop.*, Sir W. R. Wilde, M.D.	W. T. Thiselton-Dyer, R. O. Cunningham, Dr. J. J. Charles, Dr. P. H. Pye-Smith, J. J. Murphy, F. W. Rudler.
1875. Bristol	P. L. Sclater, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Cleland, M.D., F.R.S.—*Dep. of Anthropol.*, Prof. Rolleston, M.D., F.R.S.	E. R. Alston, Dr. McKendrick, Prof. W. R. M'Nab, Dr. Martyn, F. W. Rudler, Dr. P. H. Pye-Smith, Dr. W. Spencer.
1876. Glasgow ...	A. Russel Wallace, F.R.G.S., F.L.S.—*Dep. of Zool. and Bot.*, Prof. A. Newton, M.A., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. J. G. McKendrick, F.R.S.E.	E. R. Alston, Hyde Clarke, Dr. Knox, Prof. W. R. M'Nab, Dr. Muirhead, Prof. Morrison Watson.
1877. Plymouth...	J. Gwyn Jeffreys, LL.D., F.R.S., F.L.S.—*Dep. of Anat. and Physiol.*, Prof. Macalister, M.D.—*Dep. of Anthropol.*, Francis Galton, M.A., F.R.S.	E. R. Alston, F. Brent, Dr. D. J. Cunningham, Dr. C. A. Hingston, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler.
1878. Dublin	Prof. W. H. Flower, F.R.S.—*Dep. of Anthropol.*, Prof. Huxley, Sec. R.S.—*Dep. of Anat. and Physiol.*, R. McDonnell, M.D., F.R.S.	Dr. R. J. Harvey, Dr. T. Hayden, Prof. W. R. M'Nab, Prof. J. M. Purser, J. B. Rowe, F. W. Rudler.
1879. Sheffield ...	Prof. St. George Mivart, F.R.S.—*Dep. of Anthropol.*, E. B. Tylor, D.C.L., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. Pye-Smith.	Arthur Jackson, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler, Prof. Schäfer.

ANATOMICAL AND PHYSIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, V.—ANATOMY AND PHYSIOLOGY.

1833. Cambridge	Dr. Haviland	Dr. Bond, Mr. Paget.
1834. Edinburgh	Dr. Abercrombie	Dr. Roget, Dr. William Thomson.

SECTION E. (UNTIL 1847.)—ANATOMY AND MEDICINE.

1835. Dublin	Dr. Pritchard.....	Dr. Harrison, Dr. Hart.
1836. Bristol	Dr. Roget, F.R.S.	Dr. Symonds.
1837. Liverpool...	Prof. W. Clark, M.D.	Dr. J. Carson, jun., James Long, Dr. J. R. W. Vose.
1838. Newcastle	T. E. Headlam, M.D.	T. M. Greenhow, Dr. J. R. W. Vose.
1839. Birmingham	John Yelloly, M.D., F.R.S....	Dr. G. O. Rees, F. Ryland.
1840. Glasgow ...	James Watson, M.D.	Dr. J. Brown, Prof. Couper, Prof. Reid.

Date and Place	Presidents	Secretaries
1841. Plymouth ...	P. M. Roget, M.D., Sec. R.S.	Dr. J. Butter, J. Fuge, Dr. R. S. Sargent.
1842. Manchester	Edward Holme, M.D., F.L.S.	Dr. Chaytor, Dr. R. S. Sargent.
1843. Cork	Sir James Pitcairn, M.D. ...	Dr. John Popham, Dr. R. S. Sargent.
1844 York	J. C. Pritchard, M.D.	I. Erichsen, Dr. R. S. Sargent.
	SECTION E.—PHYSIOLOGY.	
1845. Cambridge	Prof. J. Haviland, M.D.	Dr. R. S. Sargent, Dr. Webster.
1846. Southampton	Prof. Owen, M.D., F.R.S. ...	C. P. Keele, Dr. Laycock, Dr. Sargent.
1847. Oxford [1] ...	Prof. Ogle, M.D., F.R.S.	Dr. Thomas K. Chambers, W. P. Ormerod.
	PHYSIOLOGICAL SUBSECTIONS OF SECTION D.	
1850. Edinburgh	Prof. Bennett, M.D., F.R.S.E.	
1855. Glasgow ...	Prof. Allen Thomson, F.R.S.	Prof. J. H. Corbett, Dr. J. Struthers.
1857. Dublin.....	Prof. R. Harrison, M.D.	Dr. R. D. Lyons, Prof. Redfern.
1858. Leeds	Sir Benjamin Brodie, Bart., F.R.S.	C. G. Wheelhouse.
1859. Aberdeen...	Prof. Sharpey, M.D., Sec.R.S.	Prof. Bennett, Prof. Redfern.
1860. Oxford.....	Prof. G. Rolleston, M.D., F.L.S.	Dr. R. M'Donnell, Dr. Edward Smith.
1861. Manchester	Dr. John Davy, F.R.S.L. & E.	Dr. W. Roberts, Dr. Edward Smith.
1862. Cambridge	C. E. Paget, M.D.....	G. F. Helm, Dr. Edward Smith.
1863. Newcastle	Prof. Rolleston, M.D., F.R.S.	Dr. D. Embleton, Dr. W. Turner.
1864. Bath.....	Dr. Edward Smith, LL.D., F.R.S.	J. S. Bartrum, Dr. W. Turner.
1865. Birminghm.[2]	Prof. Acland, M.D., LL.D., F.R.S.	Dr. A. Fleming, Dr. P. Heslop, Oliver Pembleton, Dr. W. Turner.

GEOGRAPHICAL AND ETHNOLOGICAL SCIENCES.

[For Presidents and Secretaries for Geography previous to 1851, see Section C, p. xxxviii.]

ETHNOLOGICAL SUBSECTIONS OF SECTION D.

1846.Southampton	Dr. Pritchard.....	Dr. King.
1847. Oxford.....	Prof. H. H. Wilson, M.A. ...	Prof. Buckley.
1848. Swansea ...	.....	G. Grant Francis.
1849. Birmingham	.....	Dr. R. G. Latham.
1850. Edinburgh	Vice-Admiral Sir A. Malcolm	Daniel Wilson.

SECTION E.—GEOGRAPHY AND ETHNOLOGY.

1851. Ipswich ...	Sir R. I. Murchison, F.R.S., Pres. R.G.S.	R. Cull, Rev. J. W. Donaldson, Dr. Norton Shaw.
1852. Belfast.....	Col. Chesney, R.A., D.C.L., F.R.S.	R. Cull, R. MacAdam, Dr. Norton Shaw.
1853. Hull	R. G. Latham, M.D., F.R.S.	R. Cull, Rev. H. W. Kemp, Dr. Norton Shaw.
1854. Liverpool...	Sir R. I. Murchison, D.C.L., F.R.S.	Richard Cull, Rev. H. Higgins, Dr. Ihne, Dr. Norton Shaw.

[1] By direction of the General Committee at Oxford, Sections D and E were incorporated under the name of "Section D—Zoology and Botany, including Physiology" (see p. xl). The Section being then vacant was assigned in 1851 to Geography.

[2] *Vide* note on page xli.

Date and Place	Presidents	Secretaries
1855. Glasgow ...	Sir J. Richardson, M.D., F.R.S.	Dr. W. G. Blackie, R. Cull, Dr. Norton Shaw.
1856. Cheltenham	Col. Sir H. C. Rawlinson, K.C.B.	R. Cull, F. D. Hartland, W. H. Rumsey, Dr. Norton Shaw.
1857. Dublin.....	Rev. Dr. J. Henthorn Todd, Pres. R.I.A.	R. Cull, S. Ferguson, Dr. R. R. Madden, Dr. Norton Shaw.
1858. Leeds	Sir R. I. Murchison, G.C.St.S., F.R.S.	R. Cull, Francis Galton, P. O'Callaghan, Dr. Norton Shaw, Thomas Wright.
1859. Aberdeen...	Rear-Admiral Sir James Clerk Ross, D.C.L., F.R.S.	Richard Cull, Prof. Geddes, Dr. Norton Shaw.
1860. Oxford.....	Sir R. I. Murchison, D.C.L., F.R.S.	Capt. Burrows, Dr. J. Hunt, Dr. C. Lemprière, Dr. Norton Shaw.
1861. Manchester	John Crawfurd, F.R.S.....	Dr. J. Hunt, J. Kingsley, Dr. Norton Shaw, W. Spottiswoode.
1862. Cambridge	Francis Galton, F.R.S.....	J. W. Clarke, Rev. J. Glover, Dr. Hunt, Dr. Norton Shaw, T. Wright.
1863. Newcastle	Sir R. I. Murchison, K.C.B., F.R.S.	C. Carter Blake, Hume Greenfield, C. R. Markham, R. S. Watson.
1864. Bath.....	Sir R. I. Murchison, K.C.B., F.R.S.	H. W. Bates, C. R. Markham, Capt. R. M. Murchison, T. Wright.
1865. Birmingham	Major-General Sir H. Rawlinson, M.P., K.C.B., F.R.S.	H. W. Bates, S. Evans, G. Jabet, C. R. Markham, Thomas Wright.
1866. Nottingham	Sir Charles Nicholson, Bart., LL.D.	H. W. Bates, Rev. E. T. Cusins, R. H. Major, Clements R. Markham, D. W. Nash, T. Wright.
1867. Dundee ...	Sir Samuel Baker, F.R.G.S.	H. W. Bates, Cyril Graham, C. R. Markham, S. J. Mackie, R. Sturrock.
1868. Norwich ...	Capt. G. H. Richards, R.N., F.R.S.	T. Baines, H. W. Bates, C. R. Markham, T. Wright.

SECTION E (*continued*).—GEOGRAPHY.

1869. Exeter	Sir Bartle Frere, K.C.B., LL.D., F.R.G.S.	H. W. Bates, Clements R. Markham, J. H. Thomas.
1870. Liverpool...	Sir R. I. Murchison, Bt., K.C.B., LL.D., D.C.L., F.R.S., F.G.S.	H. W. Bates, David Buxton, Albert J. Mott, Clements R. Markham.
1871. Edinburgh	Colonel Yule, C.B., F.R.G.S.	Clements R. Markham, A. Buchan, J. H. Thomas, A. Keith Johnston.
1872. Brighton ...	Francis Galton, F.R.S.....	H. W. Bates, A. Keith Johnston, Rev. J. Newton, J. H. Thomas.
1873. Bradford ...	Sir Rutherford Alcock, K.C.B.	H. W. Bates, A. Keith Johnston, Clements R. Markham.
1874. Belfast.....	Major Wilson, R.E., F.R.S., F.R.G.S.	E. G. Ravenstein, E. C. Rye, J. H. Thomas.
1875. Bristol.....	Lieut.-General Strachey, R.E., C.S.I., F.R.S., F.R.G.S., F.L.S., F.G.S.	H. W. Bates, E. C. Rye, F. F. Tuckett.
1876. Glasgow ...	Capt. Evans, C.B., F.R.S.....	H. W. Bates, E. C. Rye, R. Oliphant Wood.
1877. Plymouth...	Adm. Sir E. Ommanney, C.B., F.R.S., F.R.G.S., F.R.A.S.	H. W. Bates, F. E. Fox, E. C. Rye.
1878. Dublin.....	Prof. Sir C. Wyville Thomson, LL.D., F.R.S. L. & E.	John Coles, E. C. Rye.
1879. Sheffield ...	Clements R. Markham, C.B., F.R.S., Sec. R.G.S.	H. W. Bates, C. E. D. Black, E. C. Rye.

Date and Place	Presidents	Secretaries

STATISTICAL SCIENCE.

COMMITTEE OF SCIENCES, VI.—STATISTICS.

1833. Cambridge	Prof. Babbage, F.R.S.	J. E. Drinkwater.
1834. Edinburgh	Sir Charles Lemon, Bart.....	Dr. Cleland, C. Hope Maclean.

SECTION F.—STATISTICS.

1835. Dublin	Charles Babbage, F.R.S.	W. Greg, Prof. Longfield.
1836. Bristol.....	Sir Chas. Lemon, Bart., F.R.S.	Rev. J. E. Bromby, C. B. Fripp, James Heywood.
1837. Liverpool...	Rt. Hon. Lord Sandon	W. R. Greg, W. Langton, Dr. W. C. Tayler.
1838. Newcastle	Colonel Sykes, F.R.S.	W. Cargill, J. Heywood, W. R. Wood.
1839. Birmingham	Henry Hallam, F.R.S.	F. Clarke, R. W. Rawson, Dr. W. C. Tayler.
1840. Glasgow ...	Rt. Hon. Lord Sandon, M.P., F.R.S.	C. R. Baird, Prof. Ramsay, R. W. Rawson.
1841. Plymouth...	Lieut.-Col. Sykes, F.R.S.....	Rev. Dr. Byrth, Rev. R. Luney, R. W. Rawson.
1842. Manchester	G. W. Wood, M.P., F.L.S. ...	Rev. R. Luney, G. W. Ormerod, Dr. W. C. Tayler.
1843. Cork	Sir C. Lemon, Bart., M.P. ...	Dr. D. Bullen, Dr. W. Cooke Tayler.
1844. York.....	Lieut.-Col. Sykes, F.R.S., F.L.S.	J. Fletcher, J. Heywood, Dr. Laycock.
1845. Cambridge	Rt. Hon. the Earl Fitzwilliam	J. Fletcher, Dr. W. Cooke Tayler.
1846. Southampton	G. R. Porter, F.R.S.	J. Fletcher, F. G. P. Neison, Dr. W. C. Tayler, Rev. T. L. Shapcott.
1847. Oxford	Travers Twiss, D.C.L., F.R.S.	Rev. W. H. Cox, J. J. Danson, F. G. P. Neison.
1848. Swansea ...	J. H. Vivian, M.P., F.R.S.	J. Fletcher, Capt. R. Shortrede.
1849. Birmingham	Rt. Hon. Lord Lyttelton.....	Dr. Finch, Prof. Hancock, F. G. P. Neison.
1850. Edinburgh	Very Rev. Dr. John Lee, V.P.R.S.E.	Prof. Hancock, J. Fletcher, Dr. J. Stark.
1851. Ipswich ...	Sir John P. Boileau, Bart. ...	J. Fletcher, Prof. Hancock.
1852. Belfast.....	His Grace the Archbishop of Dublin.	Prof. Hancock, Prof. Ingram, James MacAdam, jun.
1853. Hull	James Heywood, M.P., F.R.S.	Edward Cheshire, Wm. Newmarch.
1854. Liverpool...	Thomas Tooke, F.R.S.	E. Cheshire, J. T. Danson, Dr. W. H. Duncan, W. Newmarch.
1855. Glasgow ...	R. Monckton Milnes, M.P. ...	J. A. Campbell, E. Cheshire, W. Newmarch, Prof. R. H. Walsh.

SECTION F (*continued*).—ECONOMIC SCIENCE AND STATISTICS.

1856. Cheltenham	Rt. Hon. Lord Stanley, M.P.	Rev. C. H. Bromby, E. Cheshire, Dr. W. N. Hancock, W. Newmarch, W. M. Tartt.
1857. Dublin	His Grace the Archbishop of Dublin, M.R.I.A.	Prof. Cairns, Dr. H. D. Hutton, W. Newmarch.
1858. Leeds	Edward Baines	T. B. Baines, Prof. Cairns, S. Brown, Capt. Fishbourne, Dr. J. Strang.
1859. Aberdeen...	Col. Sykes, M.P., F.R.S.	Prof. Cairns, Edmund Macrory, A. M. Smith, Dr. John Strang.
1860. Oxford	Nassau W. Senior, M.A.	Edmund Macrory, W. Newmarch, Rev. Prof. J. E. T. Rogers.

Date and Place	Presidents	Secretaries
1861. Manchester	William Newmarch, F.R.S....	David Chadwick, Prof. R. C. Christie, E. Macrory, Rev. Prof. J. E. T. Rogers.
1862. Cambridge	Edwin Chadwick, C.B.	H. D. Macleod, Edmund Macrory.
1863. Newcastle .	William Tite, M.P., F.R.S. ...	T. Doubleday, Edmund Macrory, Frederick Purdy, James Potts.
1864. Bath	William Farr, M.D., D.C.L., F.R.S.	E. Macrory, E. T. Payne, F. Purdy.
1865. Birmingham	Rt. Hon. Lord Stanley, LL.D., M.P.	G. J. D. Goodman, G. J. Johnston, E. Macrory.
1866. Nottingham	Prof. J. E. T. Rogers.....	R. Birkin, jun., Prof. Leone Levi, E. Macrory.
1867. Dundee	M. E. Grant Duff, M.P.	Prof. Leone Levi, E. Macrory, A. J. Warden.
1868. Norwich	Samuel Brown, Pres. Instit. Actuaries.	Rev. W. C. Davie, Prof. Leone Levi.
1869. Exeter	Rt. Hon. Sir Stafford H. Northcote, Bart., C.B., M.P.	Edmund Macrory, Frederick Purdy, Charles T. D. Acland.
1870. Liverpool...	Prof. W. Stanley Jevons, M.A.	Chas. R. Dudley Baxter, E. Macrory, J. Miles Moss.
1871. Edinburgh	Rt. Hon. Lord Neaves	J. G. Fitch, James Meikle.
1872. Brighton ...	Prof. Henry Fawcett, M.P. ...	J. G. Fitch, Barclay Phillips.
1873. Bradford ...	Rt. Hon. W. E. Forster, M.P.	J. G. Fitch, Swire Smith.
1874. Belfast.....	Lord O'Hagan	Prof. Donnell, Frank P. Fellows, Hans MacMordie.
1875. Bristol	James Heywood, M.A., F.R.S., Pres.S.S.	F. P. Fellows, T. G. P. Hallett, E. Macrory.
1876. Glasgow ...	Sir George Campbell, K.C.S.I., M.P.	A. M'Neel Caird, T. G. P. Hallett, Dr. W. Neilson Hancock, Dr. W. Jack.
1877. Plymouth...	Rt. Hon. the Earl Fortescue	W. F. Collier, P. Hallett, J. T. Pim.
1878. Dublin	Prof. J. K. Ingram, LL.D., M.R.I.A.	W. J. Hancock, C. Molloy, J. T. Pim.
1879. Sheffield ...	G. Shaw Lefevre, M.P., Pres. S.S.	Prof. Adamson, R. E. Leader, C. Molloy.

MECHANICAL SCIENCE.

SECTION G.—MECHANICAL SCIENCE.

1836. Bristol	Davies Gilbert, D.C.L., F.R.S.	T. G. Bunt, G. T. Clark, W. West.
1837. Liverpool...	Rev. Dr. Robinson	Charles Vignoles, Thomas Webster.
1838. Newcastle	Charles Babbage, F.R.S.....	R. Hawthorn, C. Vignoles, T. Webster.
1839. Birmingham	Prof. Willis, F.R.S., and Robt. Stephenson.	W. Carpmael, William Hawkes, T. Webster.
1840. Glasgow	Sir John Robinson	J. Scott Russell, J. Thomson, J. Tod, C. Vignoles.
1841. Plymouth	John Taylor, F.R.S.	Henry Chatfield, Thomas Webster.
1842. Manchester	Rev. Prof. Willis, F.R.S.....	J. F. Bateman, J. Scott Russell, J. Thomson, Charles Vignoles.
1843. Cork	Prof. J. Macneill, M.R.I.A ...	James Thomson, Robert Mallet.
1844. York	John Taylor, F.R.S.	Charles Vignoles, Thomas Webster.
1845. Cambridge	George Rennie, F.R.S.	Rev. W. T. Kingsley.
1846. Southampton	Rev. Prof. Willis, M.A., F.R.S.	William Betts, jun., Charles Manby.
1847. Oxford.....	Rev. Professor Walker, M.A., F.R.S.	J. Glynn, R. A. Le Mesurier.

Date and Place	Presidents	Secretaries
1848. Swansea ...	Rev. Professor Walker, M.A., F.R.S.	R. A. Le Mesurier, W. P. Struvé.
1849. Birmingham	Robert Stephenson, M.P., F.R.S.	Charles Manby, W. P. Marshall.
1850. Edinburgh	Rev. R. Robinson	Dr. Lees, David Stephenson.
1851. Ipswich	William Cubitt, F.R.S.....	John Head, Charles Manby.
1852. Belfast.....	John Walker, C.E., LL.D., F.R.S.	John F. Bateman, C. B. Hancock, Charles Manby, James Thomson.
1853. Hull	William Fairbairn, C.E., F.R.S.	James Oldham, J. Thomson, W. Sykes Ward.
1854. Liverpool...	John Scott Russell, F.R.S.	John Grantham, J. Oldham, J. Thomson.
1855. Glasgow ...	W. J. Macquorn Rankine, C.E., F.R.S.	L. Hill, jun., William Ramsay, J. Thomson.
1856. Cheltenham	George Rennie, F.R.S.	C. Atherton, B. Jones, jun., H. M. Jeffery.
1857. Dublin.....	Rt. Hon. the Earl of Rosse, F.R.S.	Prof. Downing, W.T. Doyne, A. Tate, James Thomson, Henry Wright.
1858. Leeds	William Fairbairn, F.R.S. ...	J. C. Dennis, J. Dixon, H. Wright.
1859. Aberdeen...	Rev. Prof. Willis, M.A., F.R.S.	R. Abernethy, P. Le Neve Foster, H. Wright.
1860. Oxford	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, Rev. F. Harrison, Henry Wright.
1861. Manchester	J. F. Bateman, C.E., F.R.S....	P. Le Neve Foster, John Robinson, H. Wright.
1862. Cambridge	Wm. Fairbairn, LL.D., F.R.S.	W. M. Fawcett, P. Le Neve Foster.
1863. Newcastle	Rev. Prof. Willis, M.A., F.R.S.	P. Le Neve Foster, P. Westmacott, J. F. Spencer.
1864. Bath	J. Hawkshaw, F.R.S.	P. Le Neve Foster, Robert Pitt.
1865. Birmingham	Sir W. G. Armstrong, LL.D., F.R.S.	P. Le Neve Foster, Henry Lea, W. P. Marshall, Walter May.
1866. Nottingham	Thomas Hawksley, V.P.Inst. C.E., F.G.S.	P. Le Neve Foster, J. F. Iselin, M. A. Tarbottom.
1867. Dundee.....	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, John P. Smith, W. W. Urquhart.
1868. Norwich ...	G. P. Bidder, C.E., F.R.G.S.	P. Le Neve Foster, J. F. Iselin, C. Manby, W. Smith.
1869. Exeter	C. W. Siemens, F.R.S.....	P. Le Neve Foster, H. Bauerman.
1870. Liverpool...	Chas. B. Vignoles, C.E., F.R.S.	H. Bauerman, P. Le Neve Foster, T. King, J. N. Shoolbred.
1871. Edinburgh	Prof. Fleeming Jenkin, F.R.S.	H. Bauerman, Alexander Leslie, J. P. Smith.
1872. Brighton ...	F. J. Bramwell, C.E.	H. M. Brunel, P. Le Neve Foster, J. G. Gamble, J. N. Shoolbred.
1873. Bradford ...	W. H. Barlow, F.R.S.	Crawford Barlow, H. Bauerman, E. H. Carbutt, J. C. Hawkshaw, J. N. Shoolbred.
1874. Belfast.....	Prof. James Thomson, LL.D., C.E., F.R.S.E.	A. T. Atchison, J. N. Shoolbred, John Smyth, jun.
1875. Bristol	W. Froude, C.E., M.A., F.R.S.	W. R. Browne, H. M. Brunel, J. G. Gamble, J. N. Shoolbred.
1876. Glasgow ...	C. W. Merrifield, F.R.S.	W. Bottomley, jun., W. J. Millar, J. N. Shoolbred, J. P. Smith.
1877. Plymouth...	Edward Woods, C.E.	A. T. Atchison, Dr. Merrifield, J. N. Shoolbred.
1878. Dublin	Edward Easton, C.E.	A. T. Atchison, R. G. Symes, H. T. Wood.
1879. Sheffield ...	J. Robinson, Pres. Inst. Mech. Eng.	A. T. Atchison, Emerson Bainbridge, H. T. Wood.

List of Evening Lectures.

Date and Place	Lecturer	Subject of Discourse
1842. Manchester	Charles Vignoles, F.R.S.	The Principles and Construction of Atmospheric Railways.
	Sir M. I. Brunel	The Thames Tunnel.
	R. I. Murchison	The Geology of Russia.
1843. Cork	Prof. Owen, M.D., F.R.S.	The Dinornis of New Zealand.
	Prof. E. Forbes, F.R.S.	The Distribution of Animal Life in the Ægean Sea.
	Dr. Robinson	The Earl of Rosse's Telescope.
1844. York	Charles Lyell, F.R.S.	Geology of North America.
	Dr. Falconer, F.R.S.	The Gigantic Tortoise of the Siwalik Hills in India.
1845. Cambridge	G.B.Airy,F.R.S.,Astron.Royal	Progress of Terrestrial Magnetism.
	R. I. Murchison, F.R.S.	Geology of Russia.
1846. Southampton.	Prof. Owen, M.D., F.R.S.	Fossil Mammalia of the British Isles.
	Charles Lyell, F.R.S.	Valley and Delta of the Mississippi.
	W. R. Grove, F.R.S.	Properties of the Explosive substance discovered by Dr. Schönbein; also some Researches of his own on the Decomposition of Water by Heat.
1847. Oxford	Rev. Prof. B. Powell, F.R.S.	Shooting Stars.
	Prof. M. Faraday, F.R.S.	Magnetic and Diamagnetic Phenomena.
	Hugh E. Strickland, F.G.S.	The Dodo (*Didus ineptus*).
1848. Swansea	John Percy, M.D., F.R.S.	Metallurgical Operations of Swansea and its neighbourhood.
	W. Carpenter, M.D., F.R.S.	Recent Microscopical Discoveries.
1849. Birmingham	Dr. Faraday, F.R.S.	Mr. Gassiot's Battery.
	Rev. Prof. Willis, M.A., F.R.S.	Transit of different Weights with varying velocities on Railways.
1850. Edinburgh	Prof. J. H. Bennett, M.D., F.R.S.E.	Passage of the Blood through the minute vessels of Animals in connexion with Nutrition.
	Dr. Mantell, F.R.S.	Extinct Birds of New Zealand.
1851. Ipswich	Prof. R. Owen, M.D., F.R.S.	Distinction between Plants and Animals, and their changes of Form.
	G.B.Airy,F.R.S.,Astron. Royal	Total Solar Eclipse of July 28, 1851.
1852. Belfast	Prof. G. G. Stokes, D.C.L., F.R.S.	Recent discoveries in the properties of Light.
	Colonel Portlock, R.E., F.R.S.	Recent discovery of Rock-salt at Carrickfergus, and geological and practical considerations connected with it.
1853. Hull	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	Some peculiar Phenomena in the Geology and Physical Geography of Yorkshire.
	Robert Hunt, F.R.S.	The present state of Photography.
1854. Liverpool	Prof. R. Owen, M.D., F.R.S.	Anthropomorphous Apes.
	Col. E. Sabine, V.P.R.S.	Progress of researches in Terrestrial Magnetism.
1855. Glasgow	Dr. W. B. Carpenter, F.R.S.	Characters of Species.
	Lieut.-Col. H. Rawlinson	Assyrian and Babylonian Antiquities and Ethnology.
1856. Cheltenham	Col. Sir H. Rawlinson	Recent Discoveries in Assyria and Babylonia, with the results of Cuneiform research up to the present time.
	W. R. Grove, F.R.S.	Correlation of Physical Forces.
1857. Dublin	Prof. W. Thomson, F.R.S.	The Atlantic Telegraph.
	Rev. Dr. Livingstone, D.C.L.	Recent Discoveries in Africa.

Date and Place	Lecturer	Subject of Discourse
1858. Leeds	Prof. J. Phillips, LL.D., F.R.S.	The Ironstones of Yorkshire.
	Prof. R. Owen, M.D., F.R.S.	The Fossil Mammalia of Australia.
1859. Aberdeen...	Sir R. I. Murchison, D.C.L....	Geology of the Northern Highlands.
	Rev. Dr. Robinson, F.R.S. ...	Electrical Discharges in highly rarefied Media.
1860. Oxford.....	Rev. Prof. Walker, F.R.S. ...	Physical Constitution of the Sun.
	Captain Sherard Osborn, R.N.	Arctic Discovery.
1861. Manchester	Prof. W. A. Miller, M.A., F.R.S.	Spectrum Analysis.
	G. B. Airy, F.R.S., Astron. Royal	The late Eclipse of the Sun.
1862. Cambridge	Prof. Tyndall, LL.D., F.R.S.	The Forms and Action of Water.
	Prof. Odling, F.R.S.....	Organic Chemistry.
1863. Newcastle	Prof. Williamson, F.R.S.....	The Chemistry of the Galvanic Battery considered in relation to Dynamics.
	James Glaisher, F.R.S.	The Balloon Ascents made for the British Association.
1864. Bath.....	Prof. Roscoe, F.R.S.	The Chemical Action of Light.
	Dr. Livingstone, F.R.S.	Recent Travels in Africa.
1865. Birmingham	J. Beete Jukes, F.R.S.	Probabilities as to the position and extent of the Coal-measures beneath the red rocks of the Midland Counties.
1866. Nottingham	William Huggins, F.R.S. ...	The results of Spectrum Analysis applied to Heavenly Bodies.
	Dr. J. D. Hooker, F.R.S.....	Insular Floras.
1867. Dundee.....	Archibald Geikie, F.R.S.....	The Geological Origin of the present Scenery of Scotland.
	Alexander Herschel, F.R.A.S.	The present state of knowledge regarding Meteors and Meteorites.
1868. Norwich ...	J. Fergusson, F.R.S.....	Archæology of the early Buddhist Monuments.
	Dr. W. Odling, F.R.S.	Reverse Chemical Actions.
1869. Exeter	Prof. J. Phillips, LL.D., F.R.S.	Vesuvius.
	J. Norman Lockyer, F.R.S....	The Physical Constitution of the Stars and Nebulæ.
1870. Liverpool...	Prof. J. Tyndall, LL.D., F.R.S.	The Scientific Use of the Imagination.
	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	Stream-lines and Waves, in connection with Naval Architecture.
1871. Edinburgh	F. A. Abel, F.R.S.....	Some recent investigations and applications of Explosive Agents.
	E. B. Tylor, F.R.S.	The Relation of Primitive to Modern Civilization.
1872. Brighton ...	Prof. P. Martin Duncan, M.D., F.R.S.	Insect Metamorphosis.
	Prof. W. K. Clifford	The Aims and Instruments of Scientific Thought.
1873. Bradford ...	Prof. W. C. Williamson, F.R.S.	Coal and Coal Plants.
	Prof. Clerk Maxwell, F.R.S.	Molecules.
1874. Belfast	Sir John Lubbock, Bart., M.P., F.R.S.	Common Wild Flowers considered in relation to Insects.
	Prof. Huxley, F.R.S.	The Hypothesis that Animals are Automata, and its History.
1875. Bristol	W. Spottiswoode, LL.D., F.R.S.	The Colours of Polarized Light.
	F. J. Bramwell, F.R.S.....	Railway Safety Appliances.
1876. Glasgow ...	Prof. Tait, F.R.S.E.	Force.
	Sir Wyville Thomson, F.R.S.	The *Challenger* Expedition.
1877. Plymouth...	W. Warington Smyth, M.A., F.R.S.	The Physical Phenomena connected with the Mines of Cornwall and Devon.
	Prof. Odling, F.R.S.....	The new Element, Gallium.

Date and Place	Lecturer	Subject of Discourse
1878. Dublin	G. J. Romanes, F.L.S.	Animal Intelligence.
	Prof. Dewar, F.R.S.	Dissociation, or Modern Ideas of Chemical Action.
1879. Sheffield ...	W. Crookes, F.R.S.	Radiant Matter.
	Prof. E. Ray Lankester, F.R.S.	Degeneration.

Lectures to the Operative Classes.

1867. Dundee.....	Prof. J. Tyndall, LL.D., F.R.S.	Matter and Force.
1868. Norwich ...	Prof. Huxley, LL.D., F.R.S.	A Piece of Chalk.
1869. Exeter	Prof. Miller, M.D., F.R.S. ...	Experimental illustrations of the modes of detecting the Composition of the Sun and other Heavenly Bodies by the Spectrum.
1870. Liverpool...	Sir John Lubbock, Bart., M.P., F.R.S.	Savages.
1872. Brighton ...	W. Spottiswoode, LL.D., F.R.S.	Sunshine, Sea, and Sky.
1873. Bradford ...	C. W. Siemens, D.C.L., F.R.S.	Fuel.
1874. Belfast	Prof. Odling, F.R.S.....	The Discovery of Oxygen.
1875. Bristol	Dr. W. B. Carpenter, F.R.S.	A Piece of Limestone.
1876. Glasgow ...	Commander Cameron, C.B., R.N.	A Journey through Africa.
1877. Plymouth...	W. H. Preece.....	Telegraphy and the Telephone.
1879. Sheffield ...	W. E. Ayrton	Electricity as a Motive Power.

OFFICERS OF SECTIONAL COMMITTEES PRESENT AT THE SHEFFIELD MEETING.

SECTION A.—MATHEMATICS AND PHYSICS.

President.—George Johnstone Stoney, M.A., F.R.S., M.R.I.A., Secretary to the Queen's University, Ireland.

Vice-Presidents.—Rev. Samuel Earnshaw, M.A.; W. Spottiswoode, D.C.L., LL.D., Pres. R.S.; C. W. Merrifield, F.R.S.,; Dr. J. Janssen; the Earl of Rosse, F.R.S.; Professor H. A. Newton.

Secretaries.—A. H. Allen, F.C.S.; J. W. L. Glaisher, M.A., F.R.S., Sec. R.A.S.; Oliver J. Lodge, D.Sc.; Donald McAlister, B.A., B.Sc. (Recorder).

SECTION B.—CHEMISTRY.

President.—Professor Dewar, M.A., F.R.S. L. & E.

Vice-Presidents.—Professor Abel, F.R.S., Dr. Longstaff; J. Lowthian Bell, M.P., F.R.S.; W. Crookes, F.R.S.; Dr. J. H. Gladstone, F.R.S.; Dr. Gilbert, F.R.S.; A. Vernon Harcourt, M.A., F.R.S.; Professor Odling, M.B., F.R.S.; Dr. Ronalds, F.R.S.E.; H. Clifton Sorby, LL.D., F.R.S.; Professor A. W. Williamson, LL.D., F.R.S.

Secretaries.—W. Chandler Roberts, F.R.S.; J. Millar Thomson, F.C.S., (Recorder); H. S. Bell, F.C.S.

SECTION C.—GEOLOGY.

President.—Professor P. Martin Duncan, M.B., F.R.S., F.G.S.

Vice-Presidents.—Professor A. H. Green, M.A., F.G.S.; W. Pengelly, F.R.S.; Professor A. C. Ramsay, LL.D., F.R.S.; Professor W. C. Williamson, F.R.S.

Secretaries.—W. Topley, F.G.S. (Recorder); G. Blake Walker, F.G.S.

SECTION D.—BIOLOGY.

President.—Professor St. George Mivart, F.R.S., F.L.S., F.Z.S.

Vice-Presidents.—Professor Gamgee, M.D., F.R.S.; Professor Lawson, M.A., F.L.S.; Dr. Pye-Smith; E. B. Tylor, D.C.L., F.R.S.; Professor J. O. Westwood; Professor A. Newton, F.R.S.; Dr. De Bartolomé.

Secretaries.—Arthur Jackson, F.R.C.S.; Professor W. R. M'Nab, M.D. (Recorder); J. Brooking Rowe, F.L.S.; F. W. Rudler, F.G.S. (Recorder); Professor Schäfer, F.R.S. (Recorder).

SECTION E.—GEOGRAPHY.

President.—Clements R. Markham, C.B., F.R.S., F.L.S., Sec. R.G.S., F.S.A.

Vice-Presidents.—Rev. Canon Rawlinson, M.A.; Sir Rawson W. Rawson, K.C.M.G., C.B., F.R.G.S.; Lieut.-General Sir Henry Thuillier, C.S.I., F.R.S., F.R.G.S.; Captain Verney, R.N., F.R.G.S.

Secretaries.—H. W. Bates, F.L.S., Assist. Sec. R.G.S.; C. E. D. Black; E. C. Rye, F.Z.S., Librarian R.G.S. (Recorder).

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

President.—G. Shaw Lefevre, M.P., Pres. Statistical Soc.

Vice-Presidents.—Frederick Brittain; A. J. Mundella, M.P., F.S.S.; Professor Leone Levi; J. Heywood, F.R.S.

Secretaries.—Professor Adamson, M.A.; R. E. Leader, B.A.; Constantine Molloy (Recorder).

SECTION G.—MECHANICAL SCIENCE.

President.—J. Robinson, Pres. Inst. Mech. Eng.

Vice-Presidents.—W. H. Barlow, F.R.S.; Sir John Brown; E. A. Cowper; Alderman Mark Firth; R. B. Grantham, C.E., F.G.S.; Professor Osborne Reynolds, M.A., F.R.S.; Sir Joseph Whitworth, Bart., F.R.S.

Secretaries.—A. T. Atchison, M.A. (Recorder); Emerson Bainbridge; H. Trueman Wood, B.A.

THE GENERAL TREASURER'S ACCOUNT from August 14, 1878 (commencement of DUBLIN Meeting), to August 20, 1879. Not including receipts at Sheffield Meeting.

1878–9. RECEIPTS.	£	s.	d.
To Balance from last Account, Dublin Meeting	1317	1	0
Received for Life Compositions at Dublin Meeting and since	230	0	0
„ Annual Subscriptions ditto ditto	578	2	0
„ Associates' Tickets ditto ditto	1280	0	0
„ Ladies' Tickets ditto ditto	672	0	0
„ Dividends on Stock	249	13	9
„ Sale of Publications	110	14	0
Sundry small sums for Transmission of Papers to Members during Dublin Meeting	6	10	0
Interest on Deposit at London and Westminster Bank	26	5	1
Unexpended Balance of Grant made at Dublin Meeting for "Electrolysis of Metallic Solutions and Solutions of Compound Salts"	10	0	0
	£4480	5	10

1878–9. PAYMENTS.	£	s.	d.	£	s.	d.
Paid Expenses of Dublin Meeting, also Sundry Printing, Binding, Advertising, and Incidental Expenses				1231	16	8
„ Printing, Engraving, and Binding Report of 48th Meeting, Vol. XLVII. (Dublin)				585	6	3
„ Salaries (1 year)				495	0	0
„ Rent and Office Expenses (Albemarle Street—1 year)				104	5	0
„ Purchase of £1000 Consols				943	15	0
„ Grants made at Dublin Meeting:—						
Table at the Zoological Station, Naples	75	0	0			
Miocene Flora of the Basalt of the North of Ireland	20	0	0			
Illustrations for a Monograph on the Mammoth	17	0	0			
Record of Zoological Literature	100	0	0			
Composition and Structure of less known Alkaloids	25	0	0			
Exploration of Caves in Borneo	50	0	0			
Kent's Cavern Exploration	100	0	0			
Record of the Progress of Geology	100	0	0			
Fermanagh Caves Exploration	5	0	0			
Electrolysis of Metallic Solutions and Solutions of Compound Salts	25	0	0			
Anthropometric Committee	50	0	0			
Natural History of Socotra	100	0	0			
Calculation of Factor Tables for 5th and 6th Millions	150	0	0			
Circulation of Underground Waters	10	0	0			
Steering of Screw Steamers	10	0	0			
Improvements in Astronomical Clocks	30	0	0			
Marine Zoology of South Devon	20	0	0			
Determination of Mechanical Equivalent of Heat	12	15	6			
Specific Inductive Capacity of Sprengel Vacuum	40	0	0			
Tables of Sun-heat Coefficients	30	0	0			
Datum Level of the Ordnance Survey	10	0	0			
Tables of Fundamental Invariants of Algebraic Forms	36	14	9			
Atmospheric Electricity Observations in Madeira	15	0	0			
Instrument for Detecting Fire-damp in Mines	22	0	0			
Instruments for Measuring the Speed of Ships	17	1	8			
Tidal Observations in the English Channel	10	0	0			
				1080	11	11
Balance at Bank of England, Western Branch	£24	12	0			
In hands of Assistant to General Treasurer	£14	19	0			
				39	11	0
				£4480	5	10

A. W. WILLIAMSON.

August 20, 1879.

Table showing the Attendance and Receipts

Date of Meeting	Where held	Presidents	Old Life Members	New Life Members
1831, Sept. 27 ...	York	The Earl Fitzwilliam, D.C.L.	...	...
1832, June 19 ...	Oxford	The Rev. W. Buckland, F.R.S.	...	...
1833, June 25 ...	Cambridge	The Rev. A. Sedgwick, F.R.S.	...	...
1834, Sept. 8 ...	Edinburgh	Sir T. M. Brisbane, D.C.L.....	...	...
1835, Aug. 10 ...	Dublin	The Rev. Provost Lloyd, LL.D.	...	...
1836, Aug. 22 ...	Bristol	The Marquis of Lansdowne ...	...	...
1837, Sept. 11 ...	Liverpool	The Earl of Burlington, F.R.S.	...	...
1838, Aug. 10 ...	Newcastle-on-Tyne	The Duke of Northumberland	...	...
1839, Aug. 26 ...	Birmingham.....	The Rev. W. Vernon Harcourt	...	...
1840, Sept. 17 ...	Glasgow	The Marquis of Breadalbane...	...	...
1841, July 20 ...	Plymouth	The Rev. W. Whewell, F.R.S.	169	65
1842, June 23 ...	Manchester	The Lord Francis Egerton.....	303	169
1843, Aug. 17 ...	Cork	The Earl of Rosse, F.R.S.	109	28
1844, Sept. 26 ...	York	The Rev. G. Peacock, D.D. ...	226	150
1845, June 19 ...	Cambridge	Sir John F. W. Herschel, Bart.	313	36
1846, Sept. 10 ...	Southampton	Sir Roderick I. Murchison,Bart.	241	10
1847, June 23 ...	Oxford	Sir Robert H. Inglis, Bart.....	314	18
1848, Aug. 9 ...	Swansea	The Marquis of Northampton	149	3
1849, Sept. 12 ...	Birmingham.....	The Rev. T. R. Robinson, D.D.	227	12
1850, July 21 ...	Edinburgh	Sir David Brewster, K.H.	235	9
1851, July 2 ...	Ipswich	G. B. Airy, Astronomer Royal	172	8
1852, Sept. 1 ...	Belfast	Lieut.-General Sabine, F.R.S.	164	10
1853, Sept. 3 ...	Hull	William Hopkins, F.R.S.	141	13
1854, Sept. 20 ...	Liverpool	The Earl of Harrowby, F.R.S.	238	23
1855, Sept. 12 ...	Glasgow	The Duke of Argyll, F.R.S. ...	194	33
1856, Aug. 6 ...	Cheltenham	Prof. C. G. B. Daubeny, M.D.	182	14
1857, Aug. 26 ...	Dublin	The Rev.Humphrey Lloyd, D.D.	236	15
1858, Sept. 22 ...	Leeds.....	Richard Owen, M.D., D.C.L....	222	42
1859, Sept. 14 ...	Aberdeen	H.R.H. the Prince Consort ...	184	27
1860, June 27 ...	Oxford	The Lord Wrottesley, M.A. ...	286	21
1861, Sept. 4 ...	Manchester	WilliamFairbairn,LL.D.,F.R.S.	321	113
1862, Oct. 1 ...	Cambridge	The Rev. Professor Willis, M.A.	239	15
1863, Aug. 26 ...	Newcastle-on-Tyne	Sir William G. Armstrong, C.B.	203	36
1864, Sept. 13 ...	Bath	Sir Charles Lyell, Bart., M.A.	287	40
1865, Sept. 6 ...	Birmingham.....	Prof. J. Phillips, M.A., LL.D.	292	44
1866, Aug. 22 ...	Nottingham	William R. Grove, Q.C., F.R.S.	207	31
1867, Sept. 4 ...	Dundee	The Duke of Buccleuch, K.C.B.	167	25
1868, Aug. 19 ...	Norwich	Dr. Joseph D. Hooker, F.R.S.	196	18
1869, Aug. 18 ...	Exeter	Prof. G. G. Stokes, D.C.L.	204	21
1870, Sept. 14 ...	Liverpool	Prof. T. H. Huxley, LL.D.....	314	39
1871, Aug. 2 ...	Edinburgh	Prof. Sir W. Thomson, LL.D.	246	28
1872, Aug. 14 ...	Brighton	Dr. W. B. Carpenter, F.R.S. ...	245	36
1873, Sept. 17 ...	Bradford	Prof. A. W. Williamson, F.R.S.	212	27
1874, Aug. 19 ...	Belfast	Prof. J. Tyndall, LL.D., F.R.S.	162	13
1875, Aug. 25 ...	Bristol	SirJohnHawkshaw,C.E.,F.R.S.	239	36
1876, Sept. 6 ...	Glasgow	Prof. T. Andrews, M.D., F.R.S.	221	35
1877, Aug. 15 ...	Plymouth	Prof. A. Thomson, M.D., F.R.S.	173	19
1878, Aug. 14 ...	Dublin	W. Spottiswoode, M.A., F.R.S.	201	18
1879, Aug. 20 ...	Sheffield	Prof. G. J. Allman, M.D., F.R.S.	184	16

at Annual Meetings of the Association.

Attended by						Amount received during the Meeting	Sums paid on Account of Grants for Scientific Purposes	Year
Old Annual Members	New Annual Members	Associates	Ladies	Foreigners	Total	£ s. d.	£ s. d.	
...	...	...	...	...	353	.....	.....	1831
...	...	...	...	...	...	.....	.....	1832
...	...	...	...	...	900	.....	.....	1833
...	...	...	...	...	1298	.....	20 0 0	1834
...	...	...	...	...	...	.....	167 0 0	1835
...	...	...	...	...	1350	.....	435 0 0	1836
...	...	...	...	...	1840	.....	922 12 6	1837
...	...	...	1100*	...	2400	.....	932 2 2	1838
...	...	...	...	34	1438	.....	1595 11 0	1839
...	...	...	...	40	1353	.....	1546 16 4	1840
46	317	...	60*	...	891	.....	1235 10 11	1841
75	376	33†	331*	28	1315	.....	1449 17 8	1842
71	185	...	160	...	...	.....	1565 10 2	1843
45	190	9†	260	...	...	.....	981 12 8	1844
94	22	407	172	35	1079	.....	831 9 9	1845
65	39	270	196	36	857	.....	685 16 0	1846
197	40	495	203	53	1320	.....	208 5 4	1847
54	25	376	197	15	819	707 0 0	275 1 8	1848
93	33	447	237	22	1071	963 0 0	159 19 6	1849
128	42	510	273	44	1241	1085 0 0	345 18 0	1850
61	47	244	141	37	710	620 0 0	391 9 7	1851
63	60	510	292	9	1108	1085 0 0	304 6 7	1852
56	57	367	236	6	876	903 0 0	205 0 0	1853
121	121	765	524	10	1802	1882 0 0	380 19 7	1854
142	101	1094	543	26	2133	2311 0 0	480 16 4	1855
104	48	412	346	9	1115	1098 0 0	734 13 9	1856
156	120	900	569	26	2022	2015 0 0	507 15 4	1857
111	91	710	509	13	1698	1931 0 0	618 18 2	1858
125	179	1206	821	22	2564	2782 0 0	684 11 1	1859
177	59	636	463	47	1689	1604 0 0	766 19 6	1860
184	125	1589	791	15	3138	3944 0 0	1111 5 10	1861
150	57	433	242	25	1161	1089 0 0	1293 16 6	1862
154	209	1704	1004	25	3335	3640 0 0	1608 3 10	1863
182	103	1119	1058	13	2802	2965 0 0	1289 15 8	1864
215	149	766	508	23	1997	2227 0 0	1591 7 10	1865
218	105	960	771	11	2303	2469 0 0	1750 13 4	1866
193	118	1163	771	7	2444	2613 0 0	1739 4 0	1867
226	117	720	682	45‡	2004	2042 0 0	1940 0 0	1868
229	107	678	600	17	1856	1931 0 0	1622 0 0	1869
303	195	1103	910	14	2878	3096 0 0	1572 0 0	1870
311	127	976	754	21	2463	2575 0 0	1472 2 6	1871
280	80	937	912	43	2533	2649 0 0	1285 0 0	1872
237	99	796	601	11	1983	2120 0 0	1685 0 0	1873
232	85	817	630	12	1951	1979 0 0	1151 16 0	1874
307	93	884	672	17	2248	2397 0 0	960 0 0	1875
331	185	1265	712	25	2774	3023 0 0	1092 4 2	1876
238	59	446	283	11	1229	1268 0 0	1128 9 7	1877
290	93	1285	674	17	2578	2615 0 0	725 16 6	1878
239	74	529	349	13	1404	1425 0 0	1080 11 11	1879

* Ladies were not admitted by purchased Tickets until 1843.
† Tickets of Admission to Sections only. ‡ Including Ladies.

OFFICERS AND COUNCIL, 1879–80.

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The Trustees, the President and President Elect, the Presidents of former years, the Vice-Presidents and Vice-Presidents Elect, the General and Assistant General Secretaries for the present and former years, the General Treasurers for the present and former years, and the Local Treasurer and Secretaries for the ensuing Meeting.

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The Rev. T. R. Robinson, D.D.
Sir G. B. Airy, Astronomer Royal.
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The Earl of Harrowby.
The Duke of Argyll.
The Rev. H. Lloyd, D.D.
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Sir W. G. Armstrong, C.B., LL.D.
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Prof. Sir Wm. Thomson, D.C.L.
Dr. Carpenter, C.B., F.R.S.
Prof. Williamson, Ph.D., F.R.S.
Prof. Tyndall, D.C.L., F.R.S.
Sir John Hawkshaw, C.E., F.R.S.
Prof. T. Andrews, M.D., F.R.S.
Prof. Allen Thomson, F.R.S.
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W. Spottiswoode, Esq., F.R.S.
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AUDITORS.

Warren De La Rue, Esq., F.R.S. | Professor W. H. Flower, F.R.S. | Arthur Grote, Esq., F.L.S.

REPORT OF THE COUNCIL.

Report of the Council for the year 1878–9, *presented to the General Committee at Sheffield, on Wednesday, August* 20, 1879.

The Council have received Reports during the past year from the General Treasurer, and his account for the year will be laid before the General Committee this day.

The Council have been compelled, in consequence of the limited space at their disposal at the office in London, to consider how far it would be possible to reduce the number of the old Annual Volumes of the Reports of the Association in stock, and have resolved:—

1.—'To reduce the stock of volumes in each year to 200 in number, by throwing into waste or otherwise disposing of (as the General Officers may think best) all those exceeding 200 up to the year 1848 inclusive, and by throwing into waste all those exceeding 200 in subsequent years, except the Index 1831–61.'

2.—'To offer to one or more publishers single volumes 1831–48, at one-third publication price; those 1849–71 at one-half publication price, for which purpose, if necessary, to reprint the volume for 1850; and those 1872–77 at two-thirds publication price; also sets 1871–77 at one-third publication price.'

3.—'To offer the Reports to members at the same rates as before, with the additional offer of sets 1849–71 at one-half publication price.'

The Council have also had under consideration the question of their Library, for which there is no adequate space in their present London office. They have therefore decided to recommend that in future a library shall not be maintained at the office of the Association, and in order to afford facilities to the members of the Association for consulting works of reference as fully as they have hitherto enjoyed, they have made an arrangement with the University of London, whereby the books belonging to the Association will be deposited in the Library of the University at Burlington House, upon the following conditions:—

1. One copy of every book transferred by the Association to be kept in the Library of the University.

2. Members of the Association, on presenting an introduction from one of the General Officers or the Assistant Secretary, to be permitted to consult the Library of the University.

The Council recommend to the General Committee:—

'That in each Section, and in each Department of a Section, one of the Secretaries be appointed "Recorder."'

'That such Recorder shall be requested to furnish the Assistant Secretary, *before the conclusion of the Meeting*, with a copy or abstract of every Paper read in his Section or Department.'

In order to increase the facilities for issuing the Annual Reports at an early date the Council propose, in case the General Committee should concur in this recommendation, that in future it shall be an instruction to the General Officers to issue a notice to the Reporters of all Committees, and to all other persons who are likely to read Papers at any Meeting of the Association, requesting that all Reports, and Abstracts of all Papers intended to be read in the Sections, may be sent to the Assistant Secretary not later than four weeks before the Meeting, in order that, if approved of by the Organising Committees, they may be put in type before the Meeting, and that authors who comply with this request, and whose Papers are accepted, shall be furnished, *before* the Meeting, with printed copies of their Reports or Abstracts; also that no Report, Paper, or Abstract be inserted in the volume unless it is in the hands of the Assistant Secretary or Recorder, *before the conclusion of the Meeting.*

The invitation from York for 1881, received last year, will be renewed on the present occasion, and the Council have also to announce that an invitation from Leicester for 1882 or 1883 will be likewise presented.

The following Resolutions were referred by the General Committee at Dublin to the Council for consideration and action if it should seem desirable:—

1.—'That the question of the reappointment of the Committee, consisting of the Rev. H. F. Barnes-Lawrence, Mr. Spence Bate, Mr. H. E. Dresser (Secretary), Mr. J. E. Harting, Dr. Gwyn Jeffreys, Professor Newton, the Rev. Canon Tristram, and Mr. G. Shaw Lefevre, for the purpose of inquiring into the possibility of establishing a "close time," for the protection of indigenous animals, be referred to the Council for consideration; and that the Council be empowered to take such steps in the matter as they shall think most desirable in the interests of science.'

The Council decided that the Committee should be reappointed, and that in case of any action being required before the next meeting of the Association, the Committee should be instructed to report to the Council thereon.

2.—'That the attention of the Council of the Association be called to the fact that the recommendations of the Royal Commission on Science have been altogether disregarded in the Act lately passed to enable the Trustees of the British Museum to remove the Natural History Collection to South Kensington, and that the Council be requested to take such steps in the matter as they shall think most desirable in the interests of science.'

The Council drew up a memorial to the First Lord of the Treasury, calling the attention of H.M. Government to this question, and requesting Lord Beaconsfield to receive a deputation from the Council to present the Memorial. Lord Beaconsfield having been obliged to decline to receive the deputation on account of the press of public business, the memorial was forwarded to him at his request, and a reply has been received, which, together with the memorial, is given in the Appendix (I.) to this Report.

3.—'That the question of the appointment of a Committee, consisting of Mr. James Dillon, Mr. Edward Easton, Mr. P. Le Neve Foster, Captain Douglas Galton, Mr. T. Hawksley, Sir John Hawkshaw, Professor Hull, Mr. Robert Manning, Professor Prestwich, Professor Ramsay, Mr. C. E. De Rance, the Earl of Rosse, Mr. W. Shelford, Mr. J. N. Shoolbred, Mr. John Smyth, jun., Mr. G. J. Symons, and Mr. A. T. Atchison (Secretary), for the purpose of conferring with the Council as to the advisability of urging Government to take immediate action to procure unity of control of each of our principal river basins, be referred to the Council for consideration and action if it seem desirable.'

The Council resolved that it did not seem to them desirable to take any action in this matter at present.

The Committee which was appointed last year for the purpose of watching and reporting to the Council on Patent Legislation made a report to the Council, which is given in Appendix II.

A deputation of the Council and certain other members of the Association waited on the Attorney-General on May 27 with the Report, and urged the passing of the Patent Law Amendment Bill, with certain modifications. The Bill was subsequently withdrawn.

The Council announce with great regret the loss that they have sustained during the past year by the death of Mr. William Froude, F.R.S. One vacancy having been thus caused in their body, there remain only four names which it is necessary to remove from the list.

The Council propose that, in accordance with the regulations, the four retiring members shall be the following:—

F. J. Bramwell, Esq., C.E., F.R.S.	W. Pengelly, Esq., F.R.S.
Dr. W. Farr, F.R.S.	Professor J. Prestwich, F.R.S.

The Council recommend the re-election of the other ordinary members of Council, with the addition of the gentlemen whose names are distinguished by an asterisk in the following list.

Ordinary Members of the Council.

Abel, F. A., Esq., C.B., F.R.S.
Adams, Professor W. G., F.R.S.
Barlow, W. H., Esq., F.R.S.
Cayley, Professor, F.R.S.
* Easton, E., Esq., C.E.
Evans, Captain, C.B., F.R.S.
Evans, J., Esq., F.R.S.
Foster, Professor G. C., F.R.S.
Glaisher, J. W. L., Esq., F.R.S.
Heywood, J., Esq., F.R.S.
Huggins, W., Esq., F.R.S.
* Hughes, Professor T. McK., M.A.
* Jeffreys, J. Gwyn, Esq., F.R.S.
Lefevre, George Shaw, Esq., M.P.
Maskelyne, Professor N. S., F.R.S.
* Newmarch, W., Esq., F.R.S.
Newton, Professor A., F.R.S.
Ommanney, Admiral Sir E., C.B., F.R.S.
Rayleigh, Lord, F.R.S.
Rolleston, Professor G., F.R.S.
Roscoe, Professor H. E., F.R.S.
Russell, Dr. W. J., F.R.S.
Sanderson, Professor J. S. Burdon, F.R.S.
Smyth, Warrington W., Esq., F.R.S.
* Sorby, Dr. H. C., F.R.S.

APPENDIX I.

CORRESPONDENCE WITH THE TREASURY ABOUT THE NATURAL HISTORY COLLECTIONS.

(No. 1.)

British Association for the Advancement of Science,
22 Albemarle Street, London, W.
March 25, 1879.

To the Right Hon. the First Lord of the Treasury.

My Lord,—In accordance with a resolution adopted by the General Committee of the British Association for the Advancement of Science at their last meeting, the Council of the Association beg leave to call your attention to the following circumstances.

1. In their fourth Report, presented to Parliament in 1874, the Royal Commission on Scientific Instruction and the Advancement of Science, having fully considered the present state of the Natural History Departments in the British Museum, and taken evidence thereon from the principal scientific authorities of the country, state that they have come to the conclusion 'that the objections to the present system of government of the British Museum by a Board of Trustees as at present constituted, so far as relates to the Natural History Collections, are well founded, and that they have been unable to discover that the system is attended by any compensating advantages.' They, therefore, recommend:—'(1) That the occasion of the removal of these collections to the new buildings now being erected at South Kensington for their reception be taken advantage of to effect a change in the governing authority and official administration of that division of the Museum. (2) That a Director of the National Collections should be appointed by the Crown, and should have the entire administration of the establishment, under the control of a Minister of State, to whom he should be immediately responsible, and that the keepers of collections should be responsible to the Director. That the appointments of keepers and other scientific officers should be made by the Minister, after communication with the Director and with the Board of Visitors (hereinafter referred to). And that the Director should prepare the estimates, to be submitted, after consultation with the Board of Visitors, for the approval of the Minister. (3) That the present Superintendent be the first Director. (4) That a Board of Visitors be constituted. That the Board be nominated in part by the Crown, in part by the Royal and certain other scientific Societies of the metropolis, and, in the first instance, in part also by the Board of Trustees; the members to be appointed for a limited period, but to be re-eligible; and that the Board of Visitors should make annual reports to the Minister, to be laid before Parliament, on the condition, management, and requirements of the Museum, and should be empowered to give him advice on any points affecting its administration.'

2. Exactly the same view as to the desirability of effecting a change in the government of the Natural History Collections was taken in a memorial presented to the then Chancellor of the Exchequer in 1866, and signed by the Presidents and other well-known members of the Royal, Linnean, and Zoological Societies, a copy of which is appended hereto.

3. Notwithstanding these expressions of opinion, in which nearly all the leading naturalists of the day fully concur, an Act was passed at the close of the last session of Parliament by which the Trustees of the British Museum have been authorised to transfer the Natural History Collections into the new building at South Kensington without making any change whatever in the present mode of their administration.

4. The Council of the British Association feel that it is not necessary for them to press upon the Government the arguments for the changes in the administration of the Natural History Collections which have been so amply stated by the Commissioners in the Report above mentioned. The Council think it sufficient to call the attention of the Government to the fact that the provisions of the Act are directly at variance with the recommendations of the Royal Commissioners.

5. As, however, a fresh application to Parliament will be necessary in order to defray the expense of the removal of the Natural History Collections from their present situation to South Kensington, the Council of the British Association beg leave to point out to H.M. Government that the question of the administration of the Natural History Collections is one of the utmost importance as regards the future progress of Natural History in this country, and to urge upon them to take the opportunity which will thus present itself of effecting the alterations in the mode of administration of the Collections recommended by the Royal Commission.

We have the honour to be,

Your Lordship's most obedient servants,

THE COUNCIL OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Signed, for the Council,

W. SPOTTISWOODE, *President.*
DOUGLAS GALTON, } *Secretaries.*
P. L. SCLATER, }

COPY OF A MEMORIAL PRESENTED TO THE RIGHT HON. THE CHANCELLOR OF THE EXCHEQUER.

London, *May* 14, 1866.

To the Right Hon. the Chancellor of the Exchequer.

Sir,—It having been stated that the scientific men of the metropolis are, as a body, entirely opposed to the removal of the Natural History Collections from their present situation in the British Museum, we, the undersigned Fellows of the Royal, Linnean, Geological, and Zoological Societies of London, beg leave to offer to you the following expression of our opinion upon the subject.

We are of opinion that it is of fundamental importance to the progress of the Natural Sciences in this country that the administration of the National Natural History Collections should be separated from that of the Library and Art Collections, and *placed under one Officer, who should be immediately responsible to one of the Queen's Ministers.*

We regard the exact locality of the National Museum of Natural History as a question of comparatively minor importance, provided that it be conveniently accessible and within the metropolitan district.

GEORGE BENTHAM, F.R.S., F.L.S., F.Z.S.
WILLIAM B. CARPENTER, M.D., F.R.S., F.L.S., F.G.S.
W. S. DALLAS, F.L.S.
CHARLES DARWIN, F.R.S., F.L.S., F.Z.S.
F. DUCANE GODMAN, F.L.S., F.Z.S.
J. H. GURNEY, F.Z.S.
EDWARD HAMILTON, M.D., F.L.S., F.Z.S.
JOSEPH D. HOOKER, M.D., F.R.S., F.L.S., F.G.S.
THOMAS H. HUXLEY, F.R.S., V.P.Z.S., F.L.S., F.G.S.
JOHN KIRK, F.L.S., C.M.Z.S.
LILFORD, F.L.S., F.Z.S.
ALFRED NEWTON, M.A., F.L.S., F.Z.S.
W. KITCHEN PARKER, F.R.S., F.Z.S.
ANDREW RAMSAY, F.R.S., V.P.G.S.
ARTHUR RUSSELL, M.P., F.R.G.S., F.Z.S.
OSBERT SALVIN, M.A., F.L.S., F.Z.S.
P. L. SCLATER, F.R.S., F.L.S., F.Z.S.
G. SCLATER-BOOTH, M.P., F.Z.S.
S. JAMES A. SALTER, M.B., F.R.S., F.L.S., F.Z.S.
W. H. SIMPSON, M.A., F.Z.S.
J. EMERSON TENNENT, F.R.S., F.Z.S.
THOMAS THOMSON, M.D., F.R.S., F.L.S.
H. B. TRISTRAM, M.A., F.L S.
WALDEN, F.Z.S., F.L.S.
ALFRED R. WALLACE, F.R.G.S., F.Z.S.

(No. 2.)

TREASURY CHAMBERS,
July 22, 1879.

To the President and General Secretaries of the British Association for the Advancement of Science, 22 Albemarle Street, W.

Gentlemen,—I am directed by the Lords Commissioners of Her Majesty's Treasury to inform you that the First Lord of the Treasury has submitted to this Board the letter of 25th March last, wherein, on behalf of the Council of the British Association for the Advancement of Science, you call his Lordship's attention to certain recommendations made in the Fourth Report of the Royal Commission on Scientific Instruction, which was presented to Parliament in 1874, relative to the Natural History Department of the British Museum; and wherein, further, you refer to the British Museum Act, 1878, as ignoring the said recommendations, and go on to urge that the occasion of proposing to Parliament a vote towards the expense of the removal of the same collections from their present situation to South Kensington should be taken for effecting the alterations in the mode of administering them recommended by the Royal Commission.

My Lords have, in the first place, to point out that the British Museum Act, 1878, nowise prejudges the question which you raise as to changes in the administration of the collections, but is confined to authorising the removal of them to the new Museum.

In the next place, it is to be remembered that the recommendations to which you advert require further legislation, and that the vote in supply, of which a part only is necessary to be taken this session, for completing the new Museum is equally required whether the collections are to remain under the management of the Trustees of the British Museum or are to be assigned to some other authority, and therefore that this vote, like the Act of 1878, in no degree pledged either Parliament or Her Majesty's Government upon the question of the best way to administer these collections in the future.

A third point of some importance is that both the Royal Commission and the Council which you represent propose to continue in office the present Superintendent of the collections.

Under these circumstances, my Lords, while fully agreeing with you that the question of the administration of these collections is one of the utmost importance as regards the future progress of Natural History in this country, are also of opinion that there is nothing which, on a point requiring so much consideration, calls for instant decision.

They think that the reasons which led them in 1877 to constitute the present Meteorological Council, rather than to create a new Government department, are not without weight in regard to displacing the Trustees of the British Museum.

The Chairman of the Royal Commission on Scientific Instruction is himself a member of the sub-committee of the Trustees of the British Museum for the management of these collections. The same sub-committee contains other names of high rank and of scientific eminence; nor have my Lords any reason to think that the standing committee of the Trustees, nor the Trustees generally, of the British Museum are insensible to the importance of having modern science strongly represented on the sub-committee of Natural History.

The general question whether public aid to science should, in a case like the present, not be allowed to be administered by a body with a certain real independence of its own is a very wide and a very important one; nor is the present the only case which raises it.

My Lords do not intend to propose to Parliament any immediate change in the management of these collections, and they would be glad to find that the reasons

which had led to the recommendations of the Royal Commission had been found to be capable of being met without any serious departure from the principles of a more or less independent trust.

I am, Gentlemen,
Your obedient servant,
R. R. W. LINGEN.

APPENDIX II.

REPORT OF THE PATENT-LAW COMMITTEE.

N.B.—All the Scottish Members of the Committee, and several others who were not able to attend the meetings which took place in London, wish it to be noted that while concurring in all the other resolutions of the Committee, they do not agree in the propriety of suggesting the reduction of the term of twenty-one years, proposed in the Bill, to seventeen years, as the duration of a patent.

March 25, 1879.

The Committee* of the British Association, appointed for watching and reporting to the Council on Patent Legislation, beg leave to report that there are now two Bills before Parliament in respect to Patent-law. The first Bill, brought in by private members (Mr. Anderson, Mr. Mundella. and others), and the second, a Government Bill, prepared and brought in by the Attorney-General, Mr. Secretary Cross, and the Solicitor-General.

The first Bill is very short, consisting of only five clauses. It has for its objects the extension of the term of Patent-right, both for new patents and for those existing at the time the Bill might become law, from fourteen years to twenty-one years, on payment of certain sums, and a very considerable reduction in the amount of the stamp duties payable in respect of the patent.

As regards this Bill, the Committee have to report their opinion, that it should not be proceeded with, looking at the comprehensive Government measure now before the House of Commons.

With respect to the second Bill, the Government measure, the Committee have to report that it proposes to repeal the various Acts (seven in number) relating to Patent Legislation, and to substitute for them this one Act of fifty-nine clauses.

The principal novel provisions of this Bill may be summarised as follows:—

(1.) Clause 5.—In addition to the eight legal officials now acting as the Commissioners of Patents, all of whom, with the exception of the Master of the Rolls, change with the Ministry, two persons recommended by the Lord Chancellor, and three recommended by the Board of Trade, are to be appointed by her Majesty.

(2.) Clauses 7 and 8.—The provisional protection is extended for twelve months, but a complete specification must be filed, and rendered public, along with the provisional specification, at least three months before the expiration of the provisional protection.

(3.) Clause 13.—The applicant for a patent is to have an appeal to the Lord

* The Committee appointed by the British Association consisted of Dr. A. W. Williamson, Professor Sir W. Thomson, Mr. Bramwell, Mr. St. John Vincent Day, Dr. C. W. Siemens, Mr. C. W. Merrifield, Dr. Neilson Hancock, Professor Abel, Mr. J. R. Napier, Captain Douglas Galton, Mr. Newmarch, Mr. E. H. Carbutt, Mr. Macrory, and Mr. H. Trueman Wood, who, at their first meeting, passed a resolution to add to their numbers Mr. W. H. Barlow and Mr. A. T. Atchison.

Chancellor from an adverse decision by the Law Officer. At present, the appeal is only by an opponent in case of a favourable opinion by the Law Officer.

(4.) Clause 16.—On payment of certain fees from time to time, the patents to be hereafter granted are to before a term of twenty-one years, without power of prolongation.

NOTE.—This extended time is not to apply to patents existing at the date of the Bill becoming law.

(5.) Clause 17.—A patentee is to have liberty to amend his specification, not only by way of correcting error, as at present, but also by way of explanation, supplement, or otherwise, provided that the supplemental matter could properly have been included within the patent had it been in the mind of the inventor at the time the patent was taken out.

(6.) Clause 18.—The Crown is to pay royalties in the same way as a subject pays them, with this qualification, however—that the patentee shall be compelled to allow the Crown to use the invention, upon terms to be agreed, or, failing agreement, to be settled by the Treasury, with the advice and assistance of the Commissioners of Patents.

(7.) Clause 19.—The patent shall be revocable after three years, if the patentee cannot show that he has put the invention into practice by himself or his licensees, or made reasonable efforts to do so, or if he fail to grant licenses to proper persons requesting the same on terms which the Lord Chancellor may deem reasonable.

(8.) Clause 47.—The stamp duties on obtaining a patent are to be 12*l.* 10*s.* instead of 25*l.* as at present; the three years' stamp of 50*l.*, and the seven years' stamp of 100*l.*, remaining as at present, with a further payment of 100*l.*, to be made in the twelfth year, for the purpose of preventing the patent lapsing at the end of the fourteenth year, and of continuing it until the twenty-one years.

The Committee will now give the resolutions they passed upon certain details in the Bill, and they will state the reasons which have led them to pass the resolutions. They believed that the Bill if altered as they suggest would be a better Bill than it is now, but they look upon the general scope of this Bill with so much favour that they desire to refrain from any insistance of their views in respect of detail, if such insistance would be at all likely to impede the passing of the Bill this session, and they therefore beg leave to give here at the commencement of this record of their proceedings the resolution in which they affirmed their approval of the principle of the Government Bill.

It was moved by Dr. C. W. Siemens, F.R.S., &c., the Chairman of the Committee, and seconded by Mr. F. J. Bramwell, F.R.S., the Secretary of the Committee, that—

> "The Government Bill, subject to certain modifications, meets with the entire approval of this Committee."

The following paragraphs give not only the views of the Committee in respect of the modifications of those clauses which, in the judgment of the Committee, can be beneficially altered, but also the expression of the approval of the Committee of certain new clauses in the Bill, which appear to be entirely satisfactory as they now stand :—

Clause 5.—The Committee observe with regret that, while providing for extra Commissioners, no suggestion is made that these should be paid; and, indeed, in the "Memorandum" printed with the Bill, the new Commissioners are described as "unpaid." If the additional Commissioners are to be of real use, they must devote themselves continuously to the conduct of the business of the Patent Office, and this cannot be expected without adequate payment. On this point the Committee came to the following resolution :—

> Resolved unanimously,—"That this Committee is of opinion that the five Commissioners to be appointed should be paid Commissioners."

Clauses 7, 8, and 9.—The Committee consider the extension of the provisional protection to twelve months to be desirable, but they observe that, as the patent may be opposed at any time within the "prescribed time," and as "'prescribed'

means prescribed by general orders or general rules under this Act," there is nothing to render it certain that the "prescribed time" may not be so extended as to enable opposition to be made after the complete specification is published, as it must be at the end of nine months, at the latest, from the date of the patent. If the "prescribed time" were thus extended, all opponents would wait until the complete specifications were public, and then would have an opportunity of conducting their opposition with the same elaboration and expense that would be bestowed in impugning novelty by a defendant in a Patent action. The applicant also would be put to similar cost, and thus the benefit conferred upon a poor inventor by the reduction in the fees to be paid on obtaining a patent would be much more than neutralised, and in lieu of the average of nine patent causes per annum, which prevails under the present law, there would in effect be as many causes as there were oppositions to the sealing of patents. And while considering this subject, the very serious demand upon the time of the law officers which would ensue upon oppositions thus conducted must not be lost sight of. On these considerations, notwithstanding the apparent logic of the argument that at present an opponent is opposing he knows not exactly what, while under the suggested prescribed time he will be left in no doubt, the Committee are of opinion that, as a matter of practical working, opposition on open documents is not expedient.

The Committee have embodied their views on this subject in the following resolution:—

> Resolved unanimously,—"That this Committee, fearing that if oppositions are conducted on open documents, the expenses of these oppositions, and the time occupied, will be equal to that of an action upon a patent, deem it desirable that the prescribed time should not extend beyond nine months from the date of application, and that these oppositions should be conducted as at present without open documents."

Clause 13.—The Committee entirely approve of giving the applicant for a patent the same power of appeal as is possessed by his opponent.

Clause 15.—Clause 15 has not been referred to among the principal novel features, because it is a repetition of the Clauses 18, 19, and 23 of the Act of 1852, but the Committee believe an alteration might be beneficially made. Under the existing law, and under this Bill if it becomes law, an applicant for a patent whose provisional protection bears a later date than the provisional protection of another applicant may make earlier application for the seal, and if he does so it is within the power of the Lord Chancellor (and the Committee know that that power has been exercised) to date the patent of the first applicant later than that of the second, and thus the first applicant is put to a great disadvantage. Under these circumstances there is a temptation for applicants to obtain the seal as early as possible, whereas it appears to the Committee that an inventor should be encouraged, if he is in the least doubt, to use the whole of the time allowed him before he need apply for the seal to ascertain whether his supposed invention is new, and also whether it can be practically carried into operation, and that a person thus prudently acting should be, as the Committee have said, encouraged, whereas the operation of the clause would be to urge the inventor to obtain the seal as early as possible, lest, by delaying to do so, he should lose his priority as a patentee.

The Committee embodied their opinion on this point in the following resolution:—

> Resolved unanimously,—"That the Committee are of opinion that it is undesirable there should be any doubt as to priority of patent protection, arising from the rapidity with which certain formal acts may be carried out by the applicant, and they, therefore, recommend that for all purposes, and under all circumstances, the priority of patents should be reckoned as from the day of the application for provisional protection."

Clause 16.—With respect to the proposed doing away with the power of the

Privy Council to prolong a patent after fourteen years, and to the substitution for this of an extension of twenty-one years, as of right to all patentees, who, at the end of twelve years, pay a further stamp duty of 100*l.*, the Committee think it probable that so long a term as a matter of right may be objected to, and may imperil the Bill. It is true that the Privy Council now recommend prolongation to the extent, in some cases, of as much as seven years (indeed longer extensions have been recommended), but they only do so on strict proof (however useful the invention may be) that the patentee has not been sufficiently remunerated, while the twenty-one years as of right, proposed by the Bill, would obviously be accepted by every prosperous patentee, and thus a more than sufficient payment might be made by the public for the disclosure and bringing into operation of the invention. Influenced by these considerations, the Committee are inclined to suggest that the seventeen years' duration of patents in the United States might well be adopted here. If the Bill were thus modified, it would become necessary to alter the times of payment of the various stamp duties, and as the Committee are of opinion that three years from the date of the patent (which is but two years from the cessation of the provisional protection) is so short a time as in many instances not to suffice for such development of the patent as to enable the patentee to come to a right decision on the question whether he will allow his patent to lapse or to pay the stamp duty of 50*l.*, they recommend that the time for this first payment should be four years from the date of the patent.

The following is the resolution in which the Committee have embodied their opinion on this subject:—

> Resolved unanimously,—"That this Committee would have thought an extension from fourteen to seventeen years sufficient compensation for the loss of the power to apply for a prolongation, but whether the seventeen or twenty-one years be adopted as the term of the patent, the Committee are of opinion that the times of cesser and the dates of payment to carry on the patent for a certain term should be at the end of four, eight, and fourteen years from the date of the patent."

Clause 17.—The liberty to amend, by way of supplement, is, in the judgment of the Committee, a most important improvement.

Clause 18.—The Committee hold the same opinion with respect to the provision that the Crown shall pay royalties for the use of a patent. They would be glad if some better machinery could be devised for settling (failing agreement) what the royalty should be, but they have no suggestion to make on the subject.

Clause 19.—This clause, it will be seen, makes a patent voidable after three years on either of two grounds, failure to use or to properly endeavour to do so, proof of which shall be on the patentee; and refusing to grant licenses to proper persons, on terms to be imposed by the Chancellor.

It appears to the Committee that if the second of these conditions be enacted, the first is unnecessary, as it is clear that a patent cannot be regarded as an obstruction to manufacture, when any responsible manufacturer wishing to use it can do so by paying a reasonable royalty, and the Committee believe that the first condition might readily be abused, for instance, in those cases where an invention relates to subjects which from their nature cannot be, with certain classes of inventors, put into operation by the patentees themselves, such as where a scientific man unconnected with trade or commerce has made an improvement in blast furnaces or in steam navigation. In these cases the inventor is at the mercy of those who own blast furnaces, or who own ocean steamers, and it is quite conceivable that such persons might band themselves together to prevent the use of the patent during the first three years of its existence. Bearing this danger in mind of the abuse of the first condition, and looking at the fact that the existence of a patent subject to compulsory licenses would not be an impediment to the manufacture, the Committee desire to see the first condition expunged, and, as regards the second condition, they trust that the words which were in the Government Bill of 1877, may be inserted, and that thereby the proof of the need of licenses may be imposed, as in their judgment it should be upon the person seeking them.

The following is the resolution in which the Committee have embodied their opinion upon this point:—

> Resolved unanimously,—"That Sub-Section *a* should be struck out, and that Clause 19 should be altered accordingly, so as to read thus:—'The patent shall be liable at any time at the end of three years from its date to be revoked on the following ground . . . . . ':—And that the words which appear in Clause 22, Sub-Section 2, of the Bill of 1877 should be inserted on this Bill, viz., 'that it is made to appear to the Lord Chancellor that . . . . . '"

Clause 24.—The Committee now desire to call attention to Section 24 of the Bill headed "Imported Inventions." With one exception, namely, Clause *b* of Sub-Section 5, which restricts the time within which an imported invention can be patented in England to six months after the date of the earliest foreign patent, a restriction which appears to the Committee to be very undesirable, this section is practically the same as that of Section 25 of the Patent Law Amendment Act, 1852, and thus it is that the Committee have omitted all mention of it in the summary of principal changes given at the outset of this report. The Committee, however, feel so strongly that the Section 25 of the Act of 1852 was based upon the old erroneous notion of the object of a Patent-law, and is a relic of an antiquated state of things—now entirely uncalled for and mischievous—that they trust Clause 24, which practically re-enacts Clause 25 of the Act of 1852, may be expunged altogether from the Bill. The Committee desire to be allowed to explain their views on this subject. The old notion of a Patent-law was that the inventor was a person seeking to obtain a protection for himself at the expense of the public, who, it was assumed, should regard the inventor as an antagonist, and should do all they could to procure a disclosure of the invention upon the shortest possible term of payment by patent right; or, better still, by no such payment at all. It is to be feared that these erroneous notions still prevail amongst those who have not studied the subject, but those who have studied it know that a Patent-law can only be desirable so long as it is for the benefit of the community as a whole. Those also who are acquainted with the introducing of inventions know that nothing short of a person having a strong interest in developing the invention will cause it to be taken up, the more important the invention is the greater being the indisposition to adopt it, since its introduction may involve the disuse of existing plant and machinery, the expenditure of fresh capital upon plant, and the teaching of workmen to follow new processes. One who knows the subject from its very foundation has truly said, that if an invention 'were found lying in the street it would be for the benefit of the community that a father should be assigned to it, so that there might be some one having a substantial interest in urging its development.'

Clause 24 of the present Bill (25 of the Act of 1852) is based altogether on the assumption that it is to the interest of the community to be in possession of what the Committee may perhaps be pardoned for styling 'orphan inventions.'

Further, with respect to section 24 (25 of 1852) being a relic of an antiquated state of things—when the means of communication between countries were limited, and international travellers were rare, when the technical literature of one country did not circulate in other lands where a different language was spoken, it might be that if an inventor did not patent his invention in a foreign country the foreigners would remain ignorant of it, while if he did so patent it, he would afford the information to the foreigners, and that so, if after a time his foreign patent came to an end, the foreigners would be in a better position than any British subject if a patent for the invention continued to prevail here. But under the existing condition of extended travelling, and of the interchange of technical literature, the idea that the foreigner will only know of an invention from its having been patented in his country is manifestly untenable, and thus there is no reason why a man who has taken out patents in foreign countries for an invention should be on a different footing, as regards the English patent, from that on which he would have been had

he refrained from taking out those patents. Many cases of great hardship have been inflicted by virtue of this Section 25 of the Act of 1852, and harm to the public has resulted therefrom. The Committee trust that the framers of the present Bill, who are obviously desirous of introducing a measure conceived in the interest of the community at large, will not hesitate to get rid of this Section 24. The Committee have embodied their views on this subject in the following resolution:—

> Resolved unanimously,—"That the Committee advise that Clause 24 should be struck out, as they are of opinion that it would be desirable to deal with foreign inventions upon the same terms as English inventions; and they are further of opinion that the duration of an English patent should not be affected by the determination of any foreign patent."

Another detail in the Bill to which the Committee desire to call attention, is a provision in Clause 46 by which one Commissioner may be empowered to act for the whole body. This appears to the Committee to be very inexpedient, and they would be glad to see this clause altered to the form which it has as Clause 55 in the Government Bill of 1877. The resolution of the Committee on this point was as follows:—

> Resolved unanimously—"That the Committee are of opinion that paragraph 46 ought to be left the same as 55 of the Bill of 1877."

Clause 47.—With regard to the proposed reduction of the first cost of the patent from 25*l.* to 12*l.* 10*s.*, the Committee entirely concur with it, and they believe that the payment of 50*l.* at the expiration, not of three years, but as has already been mentioned, of four years, is a useful provision for getting rid of valueless patents. The other payments they also concur in, but with the modification in point of date which has been already mentioned.

Finally, the Committee respectfully suggest to the Council of the British Association that they should appoint a deputation from the Council, with such other members of the Association as the Council may select, to wait upon the Government to urge the passing of the Bill this session, with such amendments in detail as, on consideration of the report of your Committee, the 'preparers' may see fit to adopt.

For the Committee—

WILLIAM SIEMENS, Chairman.

F. J. BRAMWELL, Secretary.

Recommendations adopted by the General Committee at the Sheffield Meeting in August 1879.

[When Committees are appointed, the Member first named is regarded as the Secretary, except there is a specific nomination.]

Involving Grants of Money.

That a Committee, consisting of Dr. O. J. Lodge (Secretary), Mr. W. E. Ayrton, and Professor J. Perry, be appointed for the purpose of devising and constructing an improved form of High Insulation Key for Electrometer Work, and that the sum of 10*l.* be placed at their disposal.

That the Committee, consisting of Captain Abney (Secretary), Professor W. G. Adams, and Professor G. C. Foster, be reappointed to carry out an investigation for the purpose of fixing a Standard of White Light; and that the sum of 20*l.* be placed at their disposal.

That the Committee, consisting of Professor Everett (Secretary), Professor Sir William Thomson, Professor J. Clerk Maxwell, Mr. G. J. Symons, Professor Ramsay, Professor Geikie, Mr. J. Glaisher, Mr. Pengelly, Professor Edward Hull, Professor Ansted, Dr. Clement Le Neve Foster, Professor A. S. Herschel, Mr. G. A. Lebour, Mr. A. B. Wynne, Mr. Galloway, Mr. Joseph Dickinson, and Mr. G. F. Deacon, on Underground Temperature, be reappointed; and that the sum of 10*l.* be placed at their disposal.

That the Committee, consisting of Dr. Joule (Secretary), Professor Sir William Thomson, Professor Tait, Professor Balfour Stewart, and Professor J. Clerk Maxwell, for effecting the Determination of the Mechanical Equivalent of Heat be reappointed; and that the sum of 52*l.* 4*s.* 6*d.*, being the amount remaining unexpended of a sum of 65*l.*, granted last year, be regranted.

That the Committee, consisting of Professor Sir William Thomson (Secretary), Professor Clerk Maxwell, Professor Tait, Dr. C. W. Siemens, Mr. F. J. Bramwell, and Mr. J. T. Bottomley, for continuing secular experiments upon the Elasticity of Wires be reappointed; and that the sum of 50*l.* be placed at their disposal.

That the Committee on Luminous Meteors, consisting of Mr. James Glaisher (Secretary), Dr. Flight, Professor R. S. Ball, Mr. E. J. Lowe, and Professor A. S. Herschel, be reappointed; and that the sum of 30*l.* be placed at their disposal.

That the Committee, consisting of Professor Sir William Thomson, Professor Tait, Professor Grant, Dr. Siemens, Professor Purser, Professor G. Forbes, Mr. Horace Darwin, and Mr. G. H. Darwin (Secretary), for the Measurement of the Lunar Disturbance of Gravity, be reappointed; and that the grant of 30*l.*, which has lapsed, be renewed.

That the Committee, consisting of Professor Sylvester (Secretary), Professor Cayley, and Professor Salmon, for the purpose of calculating Tables of the Fundamental Invariants of Algebraic Forms, be reappointed; and that the sum of 50*l.* be placed at their disposal for the purpose.

That Mr. John Perry (Secretary), Professor Unwin, Professor James Thomson, and Mr. W. E. Ayrton be a Committee for the purpose of investigating the Laws of Water Friction; and that the sum of 20*l.* be placed at their disposal for the purpose.

That the Committee, consisting of Mr. W. E. Ayrton (Secretary), Dr. O. J. Lodge, Mr. J. E. H. Gordon, and Mr. J. Perry, for the purpose of accurately measuring the specific inductive capacity of a good Sprengel Vacuum, and the specific resistance of gases at different pressures, be reappointed; and that the sum of 20*l.* be placed at their disposal for the purpose.

That the Committee, consisting of the Rev. Dr. Haughton and Mr. B. Williamson, for the calculation of Tables of Sun-heat Coefficients, be reappointed; that Mr. B. Williamson be the Secretary, and that the sum of 50*l.* be placed at their disposal for the completion of the work.

That the Committee, consisting of Professor G. Forbes (Secretary), Professor W. G. Adams, and Mr. W. E. Ayrton, be reappointed for the purpose of improving an instrument for detecting the presence of Fire-damp in Mines; and that the sum of 10*l.* be placed at their disposal for the purpose.

That Mr. J. M. Thomson (Secretary), and Mr. J. E. H. Gordon be appointed a Committee to continue Researches on the Specific Inductive Capacity of certain Crystals and Paraffines; and that the sum of 25*l.* be placed at their disposal for the purchase and preparation of materials.

That Professor Dewar, Dr. Williamson, Dr. Marshall Watts, Captain Abney, Mr. G. J. Stoney, Mr. W. N. Hartley, Professor McLeod, Professor Carey Foster, Mr. A. K. Huntington, Professor Emerson Reynolds, Professor Reinold, Professor Liveing, and Mr. W. Chandler Roberts be a Committee for the purpose of reporting upon the present state of our knowledge of Spectrum Analysis; that Mr. W. Chandler Roberts be the Secretary, and that the sum of 10*l.* be placed at their disposal for the purpose.

That Dr. Wallace, Professor Dittmar, and Mr. Pattinson be a Committee for the purpose of reporting on the best means for the development of Light from Coal-gas of different qualities; that Dr. Wallace be the Secretary, and that the sum of 10*l.* be placed at their disposal for the purpose.

That Professor P. M. Duncan and Mr. G. R. Vine be a Committee for the purpose of reporting on the Carboniferous Polyzoa; that Mr. Vine be the Secretary, and that the sum of 10*l.* be placed at their disposal for the purpose.

That Professor A. Leith Adams, the Rev. Professor Haughton, Professor W. Boyd Dawkins, and Dr. J. Evans, be a Committee for the purpose of exploring the Caves of the South of Ireland; that Professor A. Leith Adams be the Secretary, and that the sum of 10*l.* be placed at their disposal for the purpose.

That Professor H. G. Seeley, Professor W. Boyd Dawkins, and Mr. C. Moore be a Committee for the purpose of reporting upon the viviparous nature of the Ichthyosauria; that Professor Seeley be the Secretary, and that the sum of 10*l.* be placed at their disposal for the purpose.

That Mr. John Evans, Sir John Lubbock, Bart., Mr. Edward Vivian, Mr. George Busk, Professor W. Boyd Dawkins, Mr. William Ayshford Sanford, Mr. John Edward Lee, and Mr. William Pengelly be a Committee for the purpose of finishing the Exploration of Kent's Cavern,

Devonshire; that Mr. Pengelly be the Secretary, and that the sum of 50*l.* be placed at their disposal for the purpose.

That Dr. J. Evans, the Rev. T. G. Bonney, Mr. W. Carruthers, Mr. F. Drew, Mr. R. Etheridge, jun., Professor G. A. Lebour, Professor L. C. Miall, Professor H. A. Nicholson, Mr. F. W. Rudler, Mr. E. B. Tawney, Mr. W. Topley, and Mr. W. Whitaker be a Committee for the purpose of carrying on the Geological Record; that Mr. Whitaker be the Secretary, and that the sum of 100*l.* be placed at their disposal for the purpose.

That Professor W. C. Williamson, and Mr. W. H. Baily be a Committee for the purpose of collecting and reporting on the Tertiary (*i.e.*, Miocene) Flora, &c., of the Basalt of the North of Ireland; that Mr. Baily be the Secretary, and that the sum of 15*l.* be placed at their disposal for the purpose, on the understanding that a collection of representative Fossils obtained be sent to the British Museum.

That Professor Hull, the Rev. H. W. Crosskey, Captain D. Galton, Mr. Glaisher, Mr. G. A. Lebour, Mr. W. Molyneux, Mr. Morton, Mr. Pengelly, Professor Prestwich, Mr. Plant, Mr. Mellard Reade, Mr. Roberts, Mr. W. Whitaker, and Mr. De Rance be a Committee for the purpose of investigating the Circulation of the Underground Waters in the Permian New Red Sandstone, and Jurassic Formations of England, and the Quantity and Character of the Water supplied to towns and districts from those formations; that Mr. De Rance be the Secretary, and that the sum of 5*l.* be placed at their disposal for the purpose.

That Dr. Pye-Smith, Professor M. Foster, and Professor Burdon Sanderson be appointed a Committee for the purpose of investigating the Influence of Bodily Exercise on the Elimination of Nitrogen (the experiments to be conducted by Mr. North); that Dr. Burdon Sanderson be the Secretary, and that the sum of 50*l.* be placed at their disposal for the purpose.

That Major-General Lane Fox and Mr. A. W. Franks be a Committee for the purpose of issuing a revised edition of the Anthropological Notes and Queries for the Use of Travellers; that Major-General Lane Fox be the Secretary, and that the sum of 20*l.* be placed at their disposal for the purpose.

That Mr. Stainton, Sir John Lubbock, and Mr. E. C. Rye be reappointed a Committee for the purpose of continuing a Record of Zoological Literature; that Mr. Stainton be the Secretary, and that the sum of 100*l.* be placed at their disposal for the purpose.

That Dr. M. Foster, Professor Rolleston, Mr. Dew-Smith, Professor Huxley, Dr. Carpenter, Dr. Gwyn Jeffreys, Mr. Sclater, Mr. F. M. Balfour, Sir C. Wyville Thomson, Professor Ray Lankester, and Mr. Sladen be reappointed a Committee for the purpose of arranging for the occupation of a table at the Zoological Station at Naples; that Mr. Sladen be the Secretary, and that the sum of 75*l.* be placed at their disposal for the purpose.

That Dr. Arthur Gamgee, Professor Schäfer, Professor Allman, and Mr. Geddes be a Committee for the purpose of conducting Palæontological and Zoological Researches in Mexico; that Mr. Geddes be the Secretary, and that the sum of 50*l.* be placed at their disposal for the purpose.

That Sir John Lubbock, Major-General Lane Fox, Professor Leith Adams, Mr. W. James Knowles, and the Rev. Dr. Grainger be a Committee for the purpose of continuing Excavations at Portstewart and elsewhere in

the North of Ireland; that Mr. W. James Knowles be the Secretary, and that the sum of 15*l.* be placed at their disposal for the purpose.

That Dr. Farr, Dr. Beddoe, Mr. Brabrook, Sir George Campbell, Mr. F. P. Fellows, Major-General Lane Fox, Mr. F. Galton, Mr. J. Park Harrison, Mr. James Heywood, Mr. P. Hallett, Professor Leone Levi, Dr. F. A. Mahomed, Sir Rawson Rawson, Mr. Charles Roberts, and Professor Rolleston be a Committee for the purpose of continuing the collection of observations on the Systematic Examination of Heights, Weights, &c., of Human Beings in the British Empire, and the publication of photographs of the typical Races of the Empire; that Mr. Brabrook be the Secretary, and that the sum of 50*l.* be placed at their disposal for the purpose.

That Mr. Bramwell, Dr. A. W. Williamson, Professor Sir W. Thomson, Mr. St. John Vincent Day, Dr. C. W. Siemens, Mr. C. W. Merrifield, Dr. Neilson Hancock, Professor Abel, Mr. J. R. Napier, Captain Douglas Galton, Mr. Newmarch, Mr. E. H. Carbutt, Mr. Macrory, Mr. H. Trueman Wood, Mr. W. H. Barlow, and Mr. A. T. Atchison be reappointed a Committee for the purpose of watching and reporting to the Council on Patent Legislation; that Mr. F. J. Bramwell be the Secretary, and that the sum of 5*l.* be placed at their disposal for the purpose.

Not involving Grants of Money.

That the Committee, consisting of Professor G. C. Foster (Secretary), Professor W. G. Adams, Professor R. B. Clifton, Professor Cayley, Professor J. D. Everett, Professor Clerk Maxwell, Lord Rayleigh, Professor G. G. Stokes, Professor Balfour Stewart, Mr. Spottiswoode, and Professor P. G. Tait, be reappointed for the purpose of endeavouring to procure Reports on the progress of the chief branches of Mathematics and Physics.

That Mr. C. W. Merrifield be requested to report on the present state of knowledge of the Application of Quadratures and Interpolation to Actual Data.

That the Committee, consisting of Dr. W. Huggins (Secretary), Professor J. Emerson Reynolds, Mr. G. J. Stoney, Mr. W. Spottiswoode, Dr. De La Rue, Dr. W. M. Watts, Professor J. Dewar, and Captain Abney, for the purpose of preparing and printing Tables of Oscillation-frequencies be reappointed.

That the Committee, consisting of Professor G. Forbes (Secretary), Professor Sir William Thomson, and Professor J. D. Everett, for the purpose of making certain observations in India, and observations on Atmospheric Electricity at Madeira, be reappointed.

That the Committee, consisting of Mr. David Gill, Professor G. Forbes, Mr. Howard Grubb, and Mr. C. H. Gimingham, be reappointed to consider the question of improvements in Astronomical Clocks.

That Professor Cayley, Professor F. Fuller, Mr. J. W. L. Glaisher, the Rev. R. Harley, Mr. R. B. Hayward, Professor Henrici, Dr. T. A. Hirst, Mr. C. W. Merrifield, Professor Bartholomew Price, Professor H. J. S. Smith, Mr. W. Spottiswoode, Mr. G. Johnstone Stoney, Professor Townsend, Mr. J. M. Wilson, and Dr. Wormell be appointed a Committee to consider and report upon the subject of Geometrical Teaching, and particularly upon the Syllabuses prepared under the authority of the Association for the Improvement of Geometrical Teaching; and that Mr. Merrifield be the Secretary.

That the Committee, consisting of Mr. Spottiswoode, Professor G. G. Stokes, Professor Cayley, Professor H. J. S. Smith, Professor Sir William Thomson, Professor Henrici, Lord Rayleigh, and Mr. J. W. L. Glaisher, on Mathematical Notation and Printing be reappointed; and that Mr. J. W. L. Glaisher be the Secretary.

That the Committee, consisting of Professor Cayley, Professor G. G. Stokes, Professor H. J. S. Smith, Professor Sir William Thomson, Mr. James Glaisher, and Mr. J. W. L. Glaisher, on Mathematical Tables be reappointed; and that Mr. J. W. L. Glaisher be the Secretary.

That a Committee, consisting of Dr. Muirhead (Secretary), Mr. C. Hockin, Professor Sir William Thomson, Professor Clerk Maxwell, Mr. W. E. Ayrton, and Mr. J. Perry, be appointed to consider the best methods of making and issuing an Authoritative Standard of Electrical Capacity.

That Professor W. G. Adams, Mr. John M. Thomson, Mr. W. N. Hartley, and Mr. James T. Bottomley be reappointed a Committee for the purpose of investigating the law of the "Electrolysis of Mixed Metallic Solutions and Solutions of Compound Salts;" and that Mr. John M. Thomson be the Secretary.

That Professor A. S. Herschel, Professor W. E. Ayrton, Professor P. M. Duncan, Professor G. A. Lebour, Mr. J. T. Dunn, and Professor J. Perry be a Committee for the purpose of preparing a final Report on experiments to determine the Thermal Conductivities of certain Rocks, showing especially the geological aspects of the investigation; and that Professor Herschel be the Secretary.

That Professor Prestwich, Professor Hughes, Professor W. Boyd Dawkins, the Rev. H. W. Crosskey, Professor L. C. Miall, Messrs. G. H. Morton, D. Mackintosh, R. H. Tiddeman, J. E. Lee, J. Plant, W. Pengelly, Dr. Deane, Mr. Molyneux, and Professor Bonney be a Committee for the purpose of recording the position, height above the sea, lithological characters, size, and origin of the Erratic Blocks of England, Wales, and Ireland, reporting other matters of interest connected with the same, and taking measures for their preservation; and that the Rev. H. W. Crosskey be the Secretary.

That Mr. R. J. Moss, Professor W. B. Dawkins, Professor E. Hull, Dr. Moss, R.N., Mr. Pengelly, Dr. A. Leith Adams, Professor O'Reilly, and Dr. J. Evans be a Committee for the purpose of obtaining information with regard to the mode of occurrence of the remains of *Cervus Megaceros* in Ireland; and that Mr. R. J. Moss be the Secretary.

That Mr. C. Spence Bate and Mr. J. Brooking Rowe be reappointed a Committee for the purpose of exploring the Marine Zoology of South Devon; and that Mr. Spence Bate be the Secretary.

That the Rev. H. F. Barnes-Lawrence, Mr. C. Spence Bate, Mr. H. E. Dresser, Mr. J. E. Harting, Mr. Gwyn Jeffreys, Mr. J. G. Shaw Lefevre, Professor Newton, and the Rev. Canon Tristram be reappointed a Committee for the purpose of inquiring into the advisability of establishing a "close time" for the protection of indigenous animals, and that it be an instruction to the Committee to report to the Council in case of any action being required; and that Mr. H. E. Dresser be the Secretary.

That Mr. Sclater, Dr. G. Hartlaub, Sir Joseph Hooker, Captain F. M. Hunter, and Lieut.-Colonel H. H. Godwin-Austen be reappointed a Committee for the purpose of investigating the Natural History of Socotra; and that Mr. Sclater be the Secretary.

That Sir George Campbell, M.P., Lord O'Hagan, Mr. Morley, M.P., Mr. Heywood, Mr. Chadwick, M.P., Mr. Shaw Lefevre, M.P., Mr. Hallett, Professor Jevons, Dr. Farr, Mr. Stephen Bourne, Mr. Hammick, Professor Leone Levi, Professor J. K. Ingram, Dr. Hancock, Mr. J. T. Pim, and Professor Adamson (with power to add to their number) be a Committee for the purpose of continuing the researches into the Incidence of Direct Taxation, with special reference to Probate, Legacy, and Succession Duty, and the Assessed Taxes; and that Professor Adamson be the Secretary.

That Mr. Mundella, M.P., Mr. James Heywood, Mr. Stephen Bourne, Mr. Charles Doncaster, the Rev. A. Bourne, Mr. Taiso Masaki, Mr. Constantine Molloy, Mr. R. J. Pye-Smith, Dr. Hancock, and Mr. Robert Wilkinson (with power to add to their number) be a Committee for the purpose of considering and reporting on the German and other Systems of teaching the Deaf to speak; and that Mr. Robert Wilkinson be the Secretary.

That Professor Leone Levi, Mr. Stephen Bourne, Mr. Brittain, Dr. Neilson Hancock, Professor Jevons, and Mr. Fellows (with power to add to the number) be a Committee for the purpose of inquiring into the present appropriation of wages and sources of income, and considering how far it is consonant with the economic progress of the people of the United Kingdom; and that Professor Leone Levi be the Secretary.

That Mr. Mundella, M.P., Mr. Shaen, Mr. Stephen Bourne, Mr. James Heywood, Mr. Wilkinson, and Dr. J. H. Gladstone (with power to add to their number) be a Committee for the purpose of reporting whether it is important that H.M. Inspectors of Elementary Schools should be appointed with reference to their ability for examining the scientific specific subjects of the code in addition to other matters; and that Dr. J. H. Gladstone be the Secretary.

That the Committee on Tidal Observations in the English Channel and in the North Sea, consisting of Sir William Thomson, Dr. J. Merrifield, Professor Osborne Reynolds, Captain Douglas Galton, and Mr. James N. Shoolbred, be reappointed, with power to add to their number, and to communicate, if necessary, with the Government; that Mr. J. F. Deacon and Mr. Rogers Field be added to the Committee; and that Mr. James N. Shoolbred be the Secretary.

Communications ordered to be printed in extenso *in the Annual Report of the Association.*

That the paper by Mr. Godwin-Austen, 'On some further evidence relating to the Range of the Palæozoic Rocks beneath the South-East of England,' be printed *in extenso* among the Reports.

That Lieutenant Temple's paper, entitled 'Hydrography past and present,' be printed *in extenso* among the Reports, with an outline map to a scale to be settled by the editor.

That the paper by Mr. Rogers Field, 'On Self-acting Intermittent Siphons,' be printed *in extenso* among the Reports, with the necessary diagrams.

Resolution referred to the Council for consideration, and action if it seem desirable.

That the Council be requested to take such further action as regards the correspondence with the Treasury about the Natural History Collections as they shall think desirable in the interests of Science.

Synopsis of Grants of Money appropriated to Scientific Purposes by the General Committee at the Sheffield Meeting in August 1879. The Names of the Members who are entitled to call on the General Treasurer for the respective Grants are prefixed.

A.—*Mathematics and Physics.*

	£	s.	d.
Lodge, Dr.—New Form of High Insulation Key	10	0	0
Adams, Prof.—Standard of White Light	20	0	0
Everett, Prof.—Underground Temperature	10	0	0
Joule, Dr.—Determination of the Mechanical Equivalent of Heat	50	0	0
Thomson, Sir W.—Elasticity of Wires	50	0	0
Glaisher, Mr.—Luminous Meteors	30	0	0
Darwin, Mr. G. H.—Lunar Disturbance of Gravity	30	0	0
Sylvester, Prof.—Fundamental Invariants	50	0	0
Perry, Mr. J.—Laws of Water Friction	20	0	0
Ayrton, Mr. W. E.—Specific Inductive Capacity of Sprengel Vacuum	20	0	0
Haughton, Rev. Prof.—Completion of Tables of Sun-heat Coefficients	50	0	0
Forbes, Prof. G.—Instrument for Detection of Fire-damp in Mines	10	0	0
Thomson, Mr. J. M.—Inductive Capacity of Crystals and Paraffines	25	0	0

B.—*Chemistry.*

Dewar, Prof.—Spectrum Analysis	10	0	0
Wallace, Dr.—Development of Light from Coal-gas	10	0	0

C.—*Geology.*

Duncan, Prof. P. M.—Report on Carboniferous Polyzoa	10	0	0
Adam, Prof. A. L.—Caves of South Ireland	10	0	0
Seeley, Prof.—Viviparous Nature of Ichthyosaurus	10	0	0
Evans, Mr. John.—Kent's Cavern Exploration	50	0	0
Evans, Mr. John.—Geological Record	100	0	0
Williamson, Prof. W. C.—Miocene Flora of the Basalt of North Ireland	15	0	0
Hull, Prof.—Underground Waters of Permian Formations	5	0	0
Carried forward	595	0	0

D.—*Biology.*

	£	s.	d.
Brought forward	595	0	0
Pye-Smith, Dr.—Elimination of Nitrogen by Bodily Exercise.	50	0	0
Fox, Major-General Lane.—Anthropological Notes	20	0	0
Stainton, Mr.—Record of Zoological Literature	100	0	0
Foster, Dr. M.—Table at Zoological Station at Naples	75	0	0
Gamgee, Dr. A.—Investigation of the Geology and Zoology of Mexico	50	0	0
Lubbock, Sir J.—Excavations at Portstewart	15	0	0

F.—*Statistics and Economic Science.*

Farr, Dr.—Anthropometry	50	0	0

G.—*Mechanics.*

Bramwell, Mr.—Patent Laws	5	0	0
	£960	0	0

The Annual Meeting in 1880.

The Meeting at Swansea will commence on Wednesday, August 25, 1880.

Place of Meeting in 1881.

The Annual Meeting of the Association in 1881 will be held at York.

General Statement of Sums which have been paid on Account of Grants for Scientific Purposes.

	£	s.	d.
1834.			
Tide Discussions	20	0	0
1835.			
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0
1836.			
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on long-continued Heat	17	1	0
Rain-Gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£435	0	0
1837.			
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	93	3	0
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£922	12	6
1838.			
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (Strength of)	60	0	0
Animal and Vegetable Substances (Preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
	£932	2	2
1839.			
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth, &c.	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	7
Cast-Iron Experiments	100	0	0
Railway Constants	28	7	2
Land and Sea Level	274	1	4
Steam-vessels' Engines	100	0	0
Stars in Histoire Céleste	171	18	6
Stars in Lacaille	11	0	0
Stars in R.A.S. Catalogue	166	16	6
Animal Secretions	10	10	0
Steam Engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0
1840.			
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phenomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4
1841.			
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0

	£	s.	d.
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	6
Railway Sections	38	1	0
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11

1842.

Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (Brit. Assoc. Cat. of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8

1843.

Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Frith of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Co-operation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture, and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological Operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Experiments on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

	£	s.	d.
1844.			
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Co-operation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East Coast of Scotland	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment in Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3
Influence of Light on Plants	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
Registering the Shocks of Earthquakes 1842	23	11	10
Structure of Fossil Shells	20	0	0
Radiata and Mollusca of the Ægean and Red Seas 1842	100	0	0
Geographical Distributions of Marine Zoology....1842	0	10	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu	10	0	0
Experiments on the Vitality of Seeds	9	0	0
Experiments on the Vitality of Seeds 1842	8	7	3
Exotic Anoplura	15	0	0
Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the Internal Constitution of Metals	50	0	0
Constant Indicator and Morin's Instrument 1842	10	0	0
	£981	12	8

	£	s.	d.
1845.			
Publications of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Co-operation	16	16	8
Meteorological Instruments at Edinburgh	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment in Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces	50	0	0
The Actinograph	15	0	0
Microscopic Structure of Shells	20	0	0
Exotic Anoplura 1843	10	0	0
Vitality of Seeds 1843	2	0	7
Vitality of Seeds 1844	7	0	0
Marine Zoology of Cornwall	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York	20	0	0
Earthquake Shocks 1843	15	14	8
	£831	9	9

	£	s.	d.
1846.			
British Association Catalogue of Stars 1844	211	15	0
Fossil Fishes of the London Clay	100	0	0
Computation of the Gaussian Constants for 1829	50	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Strength of Materials	60	0	0
Researches in Asphyxia	6	16	2
Examination of Fossil Shells	10	0	0
Vitality of Seeds 1844	2	15	10
Vitality of Seeds 1845	7	12	3
Marine Zoology of Cornwall	10	0	0
Marine Zoology of Britain	10	0	0
Exotic Anoplura 1844	25	0	0
Expenses attending Anemometers	11	7	6
Anemometers' Repairs	2	3	6
Atmospheric Waves	3	3	3
Captive Balloons 1844	8	19	8
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality in York	12	0	0
	£685	16	0

	£	s.	d.
1847.			
Computation of the Gaussian Constants for 1829	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall	10	0	0
Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4

	£	s.	d.
1848.			
Maintaining the Establishment at Kew Observatory	171	15	11
Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogue of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants	15	0	0
	£275	1	8
1849.			
Electrical Observations at Kew Observatory	50	0	0
Maintaining Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants	5	0	0
Registration of Periodical Phenomena	10	0	0
Bill on Account of Anemometrical Observations	13	9	0
	£159	19	6
1850.			
Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves	50	0	0
Periodical Phenomena	15	0	0
Meteorological Instruments, Azores	25	0	0
	£345	18	0
1851.			
Maintaining the Establishment at Kew Observatory (includes part of grant in 1849)	309	2	2
Theory of Heat	20	1	1
Periodical Phenomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7
1852.			
Maintaining the Establishment at Kew Observatory (including balance of grant for 1850)	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds	10	6	2
Strength of Boiler Plates	10	0	0
	£304	6	7

	£	s.	d.
1853.			
Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0
	£205	0	0
1854.			
Maintaining the Establishment at Kew Observatory (including balance of former grant)	330	15	4
Investigations on Flax	11	0	0
Effects of Temperature on Wrought Iron	10	0	0
Registration of Periodical Phenomena	10	0	0
British Annelida	10	0	0
Vitality of Seeds	5	2	3
Conduction of Heat	4	2	0
	£380	19	7
1855.			
Maintaining the Establishment at Kew Observatory	425	0	0
Earthquake Movements	10	0	0
Physical Aspect of the Moon	11	8	5
Vitality of Seeds	10	7	11
Map of the World	15	0	0
Ethnological Queries	5	0	0
Dredging near Belfast	4	0	0
	£480	16	4
1856.			
Maintaining the Establishment at Kew Observatory :— 1854.....£ 75 0 0 1855.....£500 0 0	575	0	0
Strickland's Ornithological Synonyms	100	0	0
Dredging and Dredging Forms	9	13	9
Chemical Action of Light	20	0	0
Strength of Iron Plates	10	0	0
Registration of Periodical Phenomena	10	0	0
Propagation of Salmon	10	0	0
	£734	13	9
1857.			
Maintaining the Establishment at Kew Observatory	350	0	0
Earthquake Wave Experiments	40	0	0
Dredging near Belfast	10	0	0
Dredging on the West Coast of Scotland	10	0	0

	£	s.	d.
Investigations into the Mollusca of California	10	0	0
Experiments on Flax	5	0	0
Natural History of Madagascar	20	0	0
Researches on British Annelida	25	0	0
Report on Natural Products imported into Liverpool	10	0	0
Artificial Propagation of Salmon	10	0	0
Temperature of Mines	7	8	0
Thermometers for Subterranean Observations	5	7	4
Life-Boats	5	0	0
	£507	15	4

1858.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Wave Experiments	25	0	0
Dredging on the West Coast of Scotland	10	0	0
Dredging near Dublin	5	0	0
Vitality of Seeds	5	5	0
Dredging near Belfast	18	13	2
Report on the British Annelida	25	0	0
Experiments on the production of Heat by Motion in Fluids	20	0	0
Report on the Natural Products imported into Scotland	10	0	0
	£618	18	2

1859.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Dublin	15	0	0
Osteology of Birds	50	0	0
Irish Tunicata	5	0	0
Manure Experiments	20	0	0
British Medusidæ	5	0	0
Dredging Committee	5	0	0
Steam-vessels' Performance	5	0	0
Marine Fauna of South and West of Ireland	10	0	0
Photographic Chemistry	10	0	0
Lanarkshire Fossils	20	0	1
Balloon Ascents	39	11	0
	£684	11	1

1860.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Dredging near Belfast	16	6	0
Dredging in Dublin Bay	15	0	0
Inquiry into the Performance of Steam-vessels	124	0	0
Explorations in the Yellow Sandstone of Dura Den	20	0	0
Chemico-mechanical Analysis of Rocks and Minerals	25	0	0
Researches on the Growth of Plants	10	0	0
Researches on the Solubility of Salts	30	0	0
Researches on the Constituents of Manures	25	0	0
Balance of Captive Balloon Accounts	1	13	6
	£766	19	6

1861.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Earthquake Experiments	25	0	0
Dredging North and East Coasts of Scotland	23	0	0
Dredging Committee :— 1860.....£50 0 0 / 1861.....£22 0 0	72	0	0
Excavations at Dura Den	20	0	0
Solubility of Salts	20	0	0
Steam-vessel Performance	150	0	0
Fossils of Lesmahago	15	0	0
Explorations at Uriconium	20	0	0
Chemical Alloys	20	0	0
Classified Index to the Transactions	100	0	0
Dredging in the Mersey and Dee	5	0	0
Dip Circle	30	0	0
Photoheliographic Observations	50	0	0
Prison Diet	20	0	0
Gauging of Water	10	0	0
Alpine Ascents	6	5	10
Constituents of Manures	25	0	0
	£1111	5	10

1862.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Patent Laws	21	6	0
Mollusca of N.-W. of America	10	0	0
Natural History by Mercantile Marine	5	0	0
Tidal Observations	25	0	0
Photoheliometer at Kew	40	0	0
Photographic Pictures of the Sun	150	0	0
Rocks of Donegal	25	0	0
Dredging Durham and Northumberland	25	0	0
Connexion of Storms	20	0	0
Dredging North-east Coast of Scotland	6	9	6
Ravages of Teredo	3	11	0
Standards of Electrical Resistance	50	0	0
Railway Accidents	10	0	0
Balloon Committee	200	0	0
Dredging Dublin Bay	10	0	0

	£	s.	d.
Dredging the Mersey	5	0	0
Prison Diet	20	0	0
Gauging of Water	12	10	0
Steamships' Performance	150	0	0
Thermo-Electric Currents	5	0	0
	£1293	16	6

1863.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Balloon Committee deficiency	70	0	0
Balloon Ascents (other expenses)	25	0	0
Entozoa	25	0	0
Coal Fossils	20	0	0
Herrings	20	0	0
Granites of Donegal	5	0	0
Prison Diet	20	0	0
Vertical Atmospheric Movements	13	0	0
Dredging Shetland	50	0	0
Dredging North-east coast of Scotland	25	0	0
Dredging Northumberland and Durham	17	3	10
Dredging Committee superintendence	10	0	0
Steamship Performance	100	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Volcanic Temperature	100	0	0
Bromide of Ammonium	8	0	0
Electrical Standards	100	0	0
—— Construction and Distribution	40	0	0
Luminous Meteors	17	0	0
Kew Additional Buildings for Photoheliograph	100	0	0
Thermo-Electricity	15	0	0
Analysis of Rocks	8	0	0
Hydroida	10	0	0
	£1608	3	10

1864.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Coal Fossils	20	0	0
Vertical Atmospheric Movements	20	0	0
Dredging Shetland	75	0	0
Dredging Northumberland	25	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Standards of Electric Resistance	100	0	0
Analysis of Rocks	10	0	0
Hydroida	10	0	0
Askham's Gift	50	0	0
Nitrite of Amyle	10	0	0
Nomenclature Committee	5	0	0
Rain-Gauges	19	15	8
Cast-Iron Investigation	20	0	0
Tidal Observations in the Humber	50	0	0
Spectral Rays	45	0	0
Luminous Meteors	20	0	0
	£1289	15	8

1865.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Balloon Committee	100	0	0
Hydroida	13	0	0
Rain-Gauges	30	0	0
Tidal Observations in the Humber	6	8	0
Hexylic Compounds	20	0	0
Amyl Compounds	20	0	0
Irish Flora	25	0	0
American Mollusca	3	9	0
Organic Acids	20	0	0
Lingula Flags Excavation	10	0	0
Eurypterus	50	0	0
Electrical Standards	100	0	0
Malta Caves Researches	30	0	0
Oyster Breeding	25	0	0
Gibraltar Caves Researches	150	0	0
Kent's Hole Excavations	100	0	0
Moon's Surface Observations	35	0	0
Marine Fauna	25	0	0
Dredging Aberdeenshire	25	0	0
Dredging Channel Islands	50	0	0
Zoological Nomenclature	5	0	0
Resistance of Floating Bodies in Water	100	0	0
Bath Waters Analysis	8	10	10
Luminous Meteors	40	0	0
	£1591	7	10

1866.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	64	13	4
Balloon Committee	50	0	0
Metrical Committee	50	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	16	0	0
Alum Bay Fossil Leaf-Bed	15	0	0
Luminous Meteors	50	0	0
Lingula Flags Excavation	20	0	0
Chemical Constitution of Cast Iron	50	0	0
Amyl Compounds	25	0	0
Electrical Standards	100	0	0
Malta Caves Exploration	30	0	0
Kent's Hole Exploration	200	0	0
Marine Fauna, &c., Devon and Cornwall	25	0	0
Dredging Aberdeenshire Coast	25	0	0
Dredging Hebrides Coast	50	0	0
Dredging the Mersey	5	0	0
Resistance of Floating Bodies in Water	50	0	0
Polycyanides of Organic Radicals	20	0	0

	£	s.	d.
Rigor Mortis	10	0	0
Irish Annelida	15	0	0
Catalogue of Crania	50	0	0
Didine Birds of Mascarene Islands	50	0	0
Typical Crania Researches	30	0	0
Palestine Exploration Fund	100	0	0
	£1750	13	4

1867.

Maintaining the Establishment of Kew Observatory	600	0	0
Meteorological Instruments, Palestine	50	0	0
Lunar Committee	120	0	0
Metrical Committee	30	0	0
Kent's Hole Explorations	100	0	0
Palestine Explorations	50	0	0
Insect Fauna, Palestine	30	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	25	0	0
Alum Bay Fossil Leaf-Bed	25	0	0
Luminous Meteors	50	0	0
Bournemouth, &c., Leaf-Beds	30	0	0
Dredging Shetland	75	0	0
Steamship Reports Condensation	100	0	0
Electrical Standards	100	0	0
Ethyl and Methyl series	25	0	0
Fossil Crustacea	25	0	0
Sound under Water	24	4	0
North Greenland Fauna	75	0	0
Do. Plant Beds.	100	0	0
Iron and Steel Manufacture	25	0	0
Patent Laws	30	0	0
	£1739	4	0

1868.

Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	120	0	0
Metrical Committee	50	0	0
Zoological Record	100	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	100	0	0
British Rainfall	50	0	0
Luminous Meteors	50	0	0
Organic Acids	60	0	0
Fossil Crustacea	25	0	0
Methyl Series	25	0	0
Mercury and Bile	25	0	0
Organic Remains in Limestone Rocks	25	0	0
Scottish Earthquakes	20	0	0
Fauna, Devon and Cornwall	30	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-Beds	50	0	0
Greenland Explorations	100	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Secondary Reptiles, &c.	30	0	0
British Marine Invertebrate Fauna	100	0	0
	£1940	0	0

1869.

Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	50	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Gases in Deep-well Water	25	0	0
British Rainfall	50	0	0
Thermal Conductivity of Iron, &c.	30	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	30	0	0
Chemical Constitution of Cast Iron	80	0	0
Iron and Steel Manufacture	100	0	0
Methyl Series	30	0	0
Organic Remains in Limestone Rocks	10	0	0
Earthquakes in Scotland	10	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-Beds	30	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	30	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Organic Acids	12	0	0
Kiltorcan Fossils	20	0	0
Chemical Constitution and Physiological Action Relations	15	0	0
Mountain Limestone Fossils	25	0	0
Utilization of Sewage	10	0	0
Products of Digestion	10	0	0
	£1622	0	0

1870.

Maintaining the Establishment of Kew Observatory	600	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Marine Fauna	20	0	0
Ears in Fishes	10	0	0
Chemical Nature of Cast Iron	80	0	0
Luminous Meteors	30	0	0
Heat in the Blood	15	0	0
British Rainfall	100	0	0
Thermal Conductivity of Iron, &c.	20	0	0
British Fossil Corals	50	0	0
Kent's Hole Explorations	150	0	0
Scottish Earthquakes	4	0	0
Bagshot Leaf-Beds	15	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Kiltorcon Quarries Fossils	20	0	0

	£	s.	d.
Mountain Limestone Fossils	25	0	0
Utilization of Sewage	50	0	0
Organic Chemical Compounds	30	0	0
Onny River Sediment	3	0	0
Mechanical Equivalent of Heat	50	0	0
	£1572	0	0

1871.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Monthly Reports of Progress in Chemistry	100	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Thermal Equivalents of the Oxides of Chlorine	10	0	0
Tidal Observations	100	0	0
Fossil Flora	25	0	0
Luminous Meteors	30	0	0
British Fossil Corals	25	0	0
Heat in the Blood	7	2	6
British Rainfall	50	0	0
Kent's Hole Explorations	150	0	0
Fossil Crustacea	25	0	0
Methyl Compounds	25	0	0
Lunar Objects	20	0	0
Fossil Coral Sections, for Photographing	20	0	0
Bagshot Leaf-Beds	20	0	0
Moab Explorations	100	0	0
Gaussian Constants	40	0	0
	£1472	2	6

1872.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	300	0	0
Metrical Committee	75	0	0
Zoological Record	100	0	0
Tidal Committee	200	0	0
Carboniferous Corals	25	0	0
Organic Chemical Compounds	25	0	0
Exploration of Moab	100	0	0
Terato-Embryological Inquiries	10	0	0
Kent's Cavern Exploration	100	0	0
Luminous Meteors	20	0	0
Heat in the Blood	15	0	0
Fossil Crustacea	25	0	0
Fossil Elephants of Malta	25	0	0
Lunar Objects	20	0	0
Inverse Wave-Lengths	20	0	0
British Rainfall	100	0	0
Poisonous Substances Antagonism	10	0	0
Essential Oils, Chemical Constitution, &c.	40	0	0
Mathematical Tables	50	0	0
Thermal Conductivity of Metals	25	0	0
	£1285	0	0

1873.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	200	0	0
Tidal Committee	400	0	0
Sewage Committee	100	0	0
Kent's Cavern Exploration	150	0	0
Carboniferous Corals	25	0	0
Fossil Elephants	25	0	0
Wave-Lengths	150	0	0
British Rainfall	100	0	0
Essential Oils	30	0	0
Mathematical Tables	100	0	0
Gaussian Constants	10	0	0
Sub-Wealden Explorations	25	0	0
Underground Temperature	150	0	0
Settle Cave Exploration	50	0	0
Fossil Flora, Ireland	20	0	0
Timber Denudation and Rainfall	20	0	0
Luminous Meteors	30	0	0
	£1685	0	0

1874.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	100	0	0
Mathematical Tables	100	0	0
Elliptic Functions	100	0	0
Lightning Conductors	10	0	0
Thermal Conductivity of Rocks	10	0	0
Anthropological Instructions, &c.	50	0	0
Kent's Cavern Exploration	150	0	0
Luminous Meteors	30	0	0
Intestinal Secretions	15	0	0
British Rainfall	100	0	0
Essential Oils	10	0	0
Sub-Wealden Explorations	25	0	0
Settle Cave Exploration	50	0	0
Mauritius Meteorological Research	100	0	0
Magnetization of Iron	20	0	0
Marine Organisms	30	0	0
Fossils, North-West of Scotland	2	10	0
Physiological Action of Light	20	0	0
Trades Unions	25	0	0
Mountain Limestone-Corals	25	0	0
Erratic Blocks	10	0	0
Dredging, Durham and Yorkshire Coasts	28	5	0
High Temperature of Bodies	30	0	0
Siemens's Pyrometer	3	6	0
Labyrinthodonts of Coal-Measures	7	15	0
	£1151	16	0

1875.

	£	s.	d.
Eliptic Functions	100	0	0
Magnetization of Iron	20	0	0
British Rainfall	120	0	0
Luminous Meteors	30	0	0
Chemistry Record	100	0	0

	£	s.	d.
Specific Volume of Liquids...	25	0	0
Estimation of Potash and Phosphoric Acid.....	10	0	0
Isometric Cresols	20	0	0
Sub-Wealden Explorations ...	100	0	0
Kent's Cavern Exploration...	100	0	0
Settle Cave Exploration	50	0	0
Earthquakes in Scotland	15	0	0
Underground Waters	10	0	0
Development of Myxinoid Fishes	20	0	0
Zoological Record.....	100	0	0
Instructions for Travellers ...	20	0	0
Intestinal Secretions	20	0	0
Palestine Exploration	100	0	0
	£960	0	0

1876.

Printing Mathematical Tables	159	4	2
British Rainfall.....	100	0	0
Ohm's Law.....	9	15	0
Tide Calculating Machine ...	200	0	0
Specific Volume of Liquids...	25	0	0
Isomeric Cresols	10	0	0
Action of Ethyl Bromobutyrate or Ethyl Sodacetoacetate.....	5	0	0
Estimation of Potash and Phosphoric Acid.....	13	0	0
Exploration of Victoria Cave, Settle	100	0	0
Geological Record.....	100	0	0
Kent's Cavern Exploration...	100	0	0
Thermal Conductivities of Rocks	10	0	0
Underground Waters	10	0	0
Earthquakes in Scotland.....	1	10	0
Zoological Record.....	100	0	0
Close Time.....	5	0	0
Physiological Action of Sound	25	0	0
Zoological Station.....	75	0	0
Intestinal Secretions	15	0	0
Physical Characters of Inhabitants of British Isles.....	13	15	0
Measuring Speed of Ships ...	10	0	0
Effect of Propeller on turning of Steam Vessels	5	0	0
	£1092	4	2

1877.

Liquid Carbonic Acids in Minerals.....	20	0	0
Elliptic Functions	250	0	0
Thermal Conductivity of Rocks	9	11	7
Zoological Record.....	100	0	0
Kent's Cavern	100	0	0
Zoological Station at Naples	75	0	0
Luminous Meteors	30	0	0
Elasticity of Wires	100	0	0
Dipterocarpæ, Report on.....	20	0	0
Mechanical Equivalent of Heat.....	35	0	0
Double Compounds of Cobalt and Nickel	8	0	0
Underground Temperatures	50	0	0
Settle Cave Explanation	100	0	0
Underground Waters in New Red Sandstone	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodacetoacetate	10	0	0
British Earthworks	25	0	0
Atmospheric Elasticity in India	15	0	0
Development of Light from Coal-gas	20	0	0
Estimation of Potash and Phosphoric Acid.....	1	18	0
Geological Record.....	100	0	0
Anthropometric Committee	34	0	0
Physiological Action of Phosphoric Acid, &c.....	15	0	0
	£1128	9	7

1878.

Exploration of Settle Caves	100	0	0
Geological Record.....	100	0	0
Investigation of Pulse Phenomena by means of Syphon Recorder	10	0	0
Zoological Station at Naples	75	0	0
Investigation of Underground Waters.....	15	0	0
Transmission of Electrical Impulses through Nerve Structure.....	30	0	0
Calculation of Factor Table of Fourth Million	100	0	0
Anthropometric Committee...	66	0	0
Chemical Composition and Structure of less known Alkaloids.....	25	0	0
Exploration of Kent's Cavern	50	0	0
Zoological Record.....	100	0	0
Fermanagh Caves Exploration	15	0	0
Thermal Conductivity of Rocks	4	16	6
Luminous Meteors.....	10	0	0
Ancient Earthworks	25	0	0
	£725	16	6

1879.

Table at the Zoological Station, Naples	75	0	0
Miocene Flora of the Basalt of the North of Ireland ...	20	0	0
Illustrations for a Monograph on the Mammoth	17	0	0
Record of Zoological Literature	100	0	0
Composition and Structure of less-known Alkaloids	25	0	0
Exploration of Caves in Borneo	50	0	0
Kent's Cavern Exploration...	100	0	0

	£	s.	d.
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Fermanagh Caves Exploration	5	0	0
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Natural History of Socotra	100	0	0
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Circulation of Underground Waters	10	0	0
Steering of Screw Steamers	10	0	0
Improvements in Astronomical Clocks	30	0	0
Marine Zoology of South Devon	20	0	0
Determination of Mechanical Equivalent of Heat	12	15	6
Specific Inductive Capacity of Sprengel Vacuum	40	0	0
Tables of Sun-heat Coefficients	30	0	0
Datum Level of the Ordnance Survey	10	0	0
Tables of Fundamental Invariants of Algebraic Forms	36	14	9
Atmospheric Electricity Observations in Madeira	15	0	0
Instrument for Detecting Fire-damp in Mines	22	0	0
Instruments for Measuring the Speed of Ships	17	1	8
Tidal Observations in the English Channel	10	0	0
	£1080	11	11

General Meetings.

On Wednesday, August 20, at 8 P.M., in the Albert Hall, William Spottiswoode, Esq., M.A., D.C.L., LL.D., Pres. R.S., President, resigned the office of President to Professor G. J. Allman, M.D., LL.D., F.R.S. L. & E., who took the Chair, and delivered an Address, for which see page 1.

On Thursday, August 21, at 8 P.M., a Soirée took place at the Cutlers' Hall.

On Friday, August 22, at 8.30 P.M., in the Albert Hall, W. Crookes, Esq., F.R.S., delivered a Discourse on 'Radiant Matter.'

On Monday, August 25, at 8.30 P.M., in the Albert Hall, Professor E. Ray Lankester, F.R.S., delivered a Discourse on 'Degeneration.'

On Tuesday, August 26, at 8 P.M., a Soirée took place at the Cutlers' Hall.

On Wednesday, August 27, at 2.30 P.M., the concluding General Meeting took place in the Albert Hall, when the Proceedings of the General Committee, and the Grants of Money for Scientific purposes, were explained to the Members.

The Meeting was then adjourned to Swansea.[1]

[1] The Meeting is appointed to commence on Wednesday, August 25, 1880.

PRESIDENT'S ADDRESS.

ADDRESS

BY

PROFESSOR G. J. ALLMAN,

M.D., LL.D., F.R.SS. L. and E., M.R.I.A., Pres. L.S.,

PRESIDENT.

It is no easy thing to find material suited to an occasion like the present. For on the one hand there is risk that a presidential address may be too special for an audience necessarily large and general, while on the other hand it may treat too much of generalities to take hold of the sympathies and command the attention of the hearers.

It may be supposed that my subject should have been suggested by the great manufacturing industries of the town which has brought us together; but I felt convinced that a worker in only the biological sciences could not do justice to the workers in so very different a field.

I am not therefore going to discourse to you of any of those great industries which make civilised society what it is,—of those practical applications of scientific truth which within the last half-century have become developed with such marvellous rapidity, and which have already become interwoven with our everyday life, as the warp of the weaver is interwoven with the woof. Such subjects must be left to other occupiers of this chair, from whom they may receive that justice which I could not pretend to give them; and I believe I shall act most wisely by keeping to a field with which my own studies have been more directly connected.

I know that there are many here present from whom I have no right to expect that previous knowledge which would justify me in dispensing with such an amount of elementary treatment as can alone bring my subject intelligibly before them, and my fellow-members of the British Association who have the advantage of being no novices in that department of biology with which I propose to occupy you, will pardon me if I address myself mainly to those for whom the field of research on which we are about to enter has now been opened for the first time.

I have chosen, then, as the matter of my address to you to-night, a subject in whose study there has during the last few years prevailed an unwonted amount of activity, resulting in the discovery of many remark-

able facts, and the justification of many significant generalisations. I propose, in short, to give you in as untechnical a form as possible some account of the most generalised expression of living matter, and of the results of the more recent researches into its nature and phenomena.

More than forty years have now passed away since the French naturalist Dujardin drew attention to the fact that the bodies of some of the lowest members of the animal kingdom consist of a structureless, semi-fluid, contractile substance, to which he gave the name of Sarcode. A similar substance occurring in the cells of plants was afterwards studied by Hugo von Mohl, and named by him Protoplasm. It remained for Max Schultze to demonstrate that the sarcode of animals and the protoplasm of plants were identical.

The conclusions of Max Schultze have been in all respects confirmed by subsequent research, and it has further been rendered certain that this same protoplasm lies at the base of all the phenomena of life, whether in the animal or the vegetable kingdom. Thus has arisen the most important and significant generalisation in the whole domain of biological science.

Within the last few years protoplasm has again been made a subject of special study, unexpected and often startling facts have been brought to light, and a voluminous literature has gathered round this new centre of research. I believe, therefore, that I cannot do better than call your attention to some of the more important results of these inquiries, and endeavour to give you some knowledge of the properties of protoplasm, and of the part it plays in the two great kingdoms of organic nature.

As has just been said, protoplasm lies at the base of every vital phenomenon. It is, as Huxley has well expressed it, 'the physical basis of life.' Wherever there is life, from its lowest to its highest manifestations, there is protoplasm; wherever there is protoplasm, there too is life. Thus co-extensive with the whole of organic nature—every vital act being referable to some mode or property of protoplasm—it becomes to the biologist what the ether is to the physicist; only that instead of being a hypothetical conception, accepted as a reality from its adequacy in the explanation of phenomena, it is a tangible and visible reality, which the chemist may analyse in his laboratory, the biologist scrutinise beneath his microscope and his dissecting needle.

The chemical composition of protoplasm is very complex, and has not been exactly determined. It may, however, be stated that protoplasm is essentially a combination of albuminoid bodies, and that its principal elements are, therefore, oxygen, carbon, hydrogen, and nitrogen. In its typical state it presents the condition of a semi-fluid substance—a tenacious, glairy liquid, with a consistence somewhat like that of the white of an unboiled egg.[1] While we watch it beneath the microscope move-

[1] In speaking of protoplasm as a liquid, it must be borne in mind that this expression refers only to its physical consistence—a condition depending mainly on the amount of water with which it is combined, and subject to considerable

ments are set up in it; waves traverse its surface, or it may be seen to flow away in streams, either broad and attaining but a slight distance from the main mass, or else stretching away far from their source, as narrow liquid threads, which may continue simple, or may divide into branches, each following its own independent course; or the streams may flow one into the other, as streamlets would flow into rivulets and rivulets into rivers, and this not only where gravity would carry them, but in a direction diametrically opposed to gravitation; now we see it spreading itself out on all sides into a thin liquid stratum, and again drawing itself together within the narrow limits which had at first confined it, and all this without any obvious impulse from without which would send the ripples over its surface or set the streams flowing from its margin. Though it is certain that all these phenomena are in response to some stimulus exerted on it by the outer world, they are such as we never meet with in a simply physical fluid—they are spontaneous movements resulting from its proper irritability, from its essential constitution as living matter.

Examine it closer, bring to bear on it the highest powers of your microscope—you will probably find disseminated through it countless multitudes of exceedingly minute granules; but you may also find it absolutely homogeneous, and, whether containing granules or not, it is certain that you will find nothing to which the term *organisation* can be applied. You have before you a glairy, tenacious fluid, which, if not absolutely homogeneous, is yet totally destitute of structure.

And yet no one who contemplates this spontaneously moving matter can deny that it is alive. Liquid as it is, it is a living liquid; organless and structureless as it is, it manifests the essential phenomena of life.

The picture which I have thus endeavoured to trace for you in a few leading outlines is that of protoplasm in its most generalised aspect. Such generalisations, however, are in themselves unable to satisfy the conditions demanded by an exact scientific inquiry, and I propose now, before passing to the further consideration of the place and purport of protoplasm in nature, to bring before you some definite examples of protoplasm, such as are actually met with in the organic world.

A quantity of a peculiar slimy matter was dredged in the North Atlantic by the naturalists of the exploring ship 'Porcupine' from a depth of from 5,000 to 25,000 feet. It is described as exhibiting, when examined on the spot, spontaneous movements, and as being obviously endowed with life. Specimens of this, preserved in spirits, were examined by Prof. Huxley, and declared by him to consist of protoplasm, vast masses of which must thus in a living state extend over wide areas of sea bottom. To this wonderful slime Huxley gave the name of *Bathybius Haeckelii.*

variation, from the solid form in which we find it in the dormant embryo of seeds, to the thin watery state in which it occurs in the leaves of Valisneria. Its distinguishing properties are totally different from those of a purely physical liquid, and are subject to an entirely different set of laws.

Bathybius has since been subjected to an exhaustive examination by Prof. Haeckel, who believes that he is able to confirm in all points the conclusions of Huxley, and arrives at the conviction that the bottom of the open ocean, at depths below 5,000 feet, is covered with an enormous mass of living protoplasm, which lingers there in the simplest and most primitive condition, having as yet acquired no definite form. He suggests that it may have originated by spontaneous generation, but leaves this question for future investigators to decide.

The reality of Bathybius, however, has not been universally accepted. In the more recent investigations of the 'Challenger' the explorers have failed in their attempts to bring further evidence of the existence of masses of amorphous protoplasm spreading over the bed of the ocean. They have met with no trace of Bathybius in any of the regions explored by them, and they believe that they are justified in the conclusion that the matter found in the dredgings of the 'Porcupine' and preserved in spirits for further examination was only an inorganic precipitate due to the action of the alcohol.

It is not easy to believe, however, that the very elaborate investigations of Huxley and Haeckel can be thus disposed of. These, moreover, have received strong confirmation from the still more recent observations of the Arctic voyager, Bessels, who was one of the explorers of the ill-fated 'Polaris,' and who states that he dredged from the Greenland seas masses of living undifferentiated protoplasm. Bessels assigns to these the name of Protobathybius, but they are apparently indistinguishable from the Bathybius of the 'Porcupine.' Further arguments against the reality of Bathybius will therefore be needed before a doctrine founded on observations so carefully conducted shall be relegated to the region of confuted hypotheses.

Assuming, then, that Bathybius, however much its supposed wide distribution may have been limited by more recent researches, has a real existence, it presents us with a condition of living matter the most rudimental it is possible to conceive. No law of morphology has as yet exerted itself in this formless slime. Even the simplest individualisation is absent. We have a living mass, but we know not where to draw its boundary lines; it is living matter, but we can scarcely call it a living being.

We are not, however, confined to Bathybius for examples of protoplasm in a condition of extreme simplicity. Haeckel has found, inhabiting the fresh waters in the neighbourhood of Jena, minute lumps of protoplasm, which when placed under the microscope were seen to have no constant shape, their outline being in a state of perpetual change, caused by the protrusion from various parts of their surface of broad lobes and thick finger-like projections, which, after remaining visible for a time, would be withdrawn, to make their appearance again on some other part of the surface.

These changeable protrusions of its substance, without fixed position

or definite form, are eminently characteristic of protoplasm in some of its simplest conditions. They have been termed 'Pseudopodia,' and will frequently come before you in what I have yet to say.

To the little protoplasmic lumps thus constituted, Haeckel has given the name of *Protamœba primitiva*. They may be compared to minute detached pieces of Bathybius. He has seen them multiplying themselves by spontaneous division into two pieces, which, on becoming independent, increase in size and acquire all the characters of the parent.

Several other beings as simple as *Protamœba* have been described by various observers, and especially by Haeckel, who brings the whole together into a group to which he gives the name of MONERA, suggested by the extreme simplicity of the beings included in it.

But we must now pass to a stage a little higher in the development of protoplasmic beings. Widely distributed in the fresh and salt waters of Britain, and probably of almost all parts of the world, are small particles of protoplasm closely resembling the *Protamœba* just described. Like it, they have no definite shape, and are perpetually changing their form, throwing out and drawing in thick lobes and finger-like pseudopodia, in which their body seems to flow away over the field of the microscope. They are no longer, however, the homogeneous particle of protoplasm which forms the body of *Protamœba*. Towards the centre a small globular mass of firmer protoplasm has become differentiated off from the remainder, and forms what is known as a nucleus, while the protoplasm forming the extreme outer boundary differs slightly from the rest, being more transparent, destitute of granules, and apparently somewhat firmer than the interior. We may also notice that at one spot a clear spherical space has made its appearance, but that while we watch it has suddenly contracted and vanished, and after a few seconds has begun to dilate so as again to come into view, once more to disappear, then again to return, and all this in regular rhythmical sequence. This little rhythmically pulsating cavity is called the 'contractile vacuole.' It is of very frequent occurrence among those beings which lie low down in the scale of life.

We have now before us a being which has arrested the attention of naturalists almost from the commencement of microscopical observation. It is the famous *Amœba*, for which ponds and pools and gutters on the house-roof have for the last 200 years been ransacked by the microscopist, who has many a time stood in amazement at the undefinable form and Protean changes of this particle of living matter. It is only the science of our own days, however, which has revealed its biological importance, and shown that in this little soft nucleated particle we have a body whose significance for the morphology and physiology of living beings cannot be overestimated, for in *Amœba* we have the essential characters of a CELL, the morphological unit of organisation, the physiological source of specialised function.

The term 'cell' has been so long in use that it cannot now be displaced from our terminology; and yet it tends to convey an incorrect notion,

suggesting, as it does, the idea of a hollow body or vesicle, this having been the form under which it was first studied. The cell, however, is essentially a definite mass of protoplasm having a nucleus imbedded in it. It may, or may not, assume the form of a vesicle; it may, or may not, be protected by an enveloping membrane; it may, or may not, contain a contractile vacuole; and the nucleus may, or may not, contain within it one or more minute secondary nuclei or 'nucleoli.'

Haeckel has done good service to biology in insisting on the necessity of distinguishing such non-nucleated forms as are presented by *Protamœba* and the other *Monera* from the nucleated forms as seen in *Amœba*. To the latter he would restrict the word *cell*, while he would assign that of 'cytode' to the former.[2]

[2] In every typical cell three parts may be distinguished. There is first the more or less liquid granular protoplasm; secondly the nucleus; and thirdly an external more firm zone of protoplasm, known as the 'cortical layer'—the Hautschicht of the German histologists. All these parts may be regarded as portions differentiated out of the original simple protoplasm. Cells do not, however, always remain on a stage of such simplicity as that presented by *Amœba*. The nucleus is always at its origin quite homogeneous, but as it increases in size it usually manifests a differentiation resulting in a constitution which recent research has shown to be more complex than had been previously supposed; for we often find it to present an external firmer layer, or nuclear membrane, including within it the softer nuclear protoplasm, in which again a network of filaments has been in many instances described.

The structure of the nucleus has been quite recently studied by Flemming (*Arch. f. Mikr. Anat.* Band xvi. Heft 2. 1878), who has given particular attention to this intranuclear network. He maintains that in its completed state the nucleus consists of a parietal firm layer, which encloses, besides specially differentiated nucleoli, a framework (Gerüst) of filaments with a more fluid intervening substance. He further insists on the fact that, with the differentiation of a nucleus, there is introduced a chemical difference between its substance and that of the surrounding cell-substance, as shown not only by a different behaviour of the nucleus towards re-agents, but by an actually determined difference of chemical composition.

Klein (*Quarterly Journ. Micr. Sci.* vol. xviii. p. 315) has shown that in the cells of the stomach of *Triton cristatus* there is a delicate intranuclear network of filaments in all respects resembling that described by Flemming; and he further maintains that the network of the nucleus is here continuous, through minute apertures near the poles of the nuclear membrane, with a similar network in the surrounding cell-substance. In this cell-substance he distinguishes two parts—the homogeneous ground-substance and the intracellular network of filaments.

Flemming, however, will not admit this connection between intra-nuclear and intra-cellular filaments, and Schleicher, as the result of his very recent researches on the division of cartilage-cells (*Die Knorpelzelltheilung*, Arch. f. Mikr. Anat. Band xvi. Heft 2, 1878), concludes that in these there is no true intra-cellular network, the nucleus being here composed of a multitude of separate rodlets, filaments, and granules surrounded by the nuclear membrane.

The minute granules which are generally seen in the soft protoplasm of the cell do not seem to be essential constituents. They are probably nutritive matter introduced from without, and in process of assimilation and conversion into proper protoplasm. Hanstein has distinguished by the term Metaplasm these granules from the proper homogeneous protoplasm in which they are suspended. The external cortical layer is quite destitute of them: on this devolves the property of protecting the contents from the unfavourable action of outer influences, and to it alone in plants is allocated the property of secreting the cellulose boundary wall.

Several recent observers, but more especially Strasburger (*Studien über das Protoplasma Jenaische Zeitschr.* 1876), have described in the cortical layer of various cells a radial striation, as if formed by excessively delicate rodlets (Stäbchen), placed vertically to the surface and in close proximity to one another. He

Let us observe our *Amœba* a little closer. Like all living beings, it must be nourished. It cannot grow as a crystal would grow by accumulating on its surface molecule after molecule of matter. It must *feed*. It must take into its substance the necessary nutriment; it must assimilate this nutriment, and convert it into the material of which it is itself composed.

If we seek, however, for a mouth by which the nutriment can enter into its body, or a stomach by which this nutriment can be digested, we seek in vain. Yet watch it for a moment as it lies in a drop of water beneath our microscope. Some living denizen of the same drop is in its neighbourhood, and its presence exerts on the protoplasm of the *Amœba* a special stimulus which gives rise to the movements necessary for the prehension of nutriment. A stream of protoplasm instantly runs away from the body of the *Amœba* towards the destined prey, envelopes it in its current, and then flows back with it to the central protoplasm, where it sinks deeper and deeper into the soft yielding mass, and becomes dissolved, digested, and assimilated in order that it may increase the size and restore the energy of its captor.

But again, like all living things, *Amœba* must multiply itself, and so after attaining a certain size its nucleus divides into two halves, and then the surrounding protoplasm becomes similarly cleft, each half retaining one half of the original nucleus. The two new nucleated masses which thus arise now lead an independent life, assimilate nutriment, and attain the size and characters of the parent.

We have just seen that in the body of an *Amœba* we have the type of a cell. Now both the fresh waters and the sea contain many living beings besides *Amœba* which never pass beyond the condition of a simple cell. Many of these, instead of emitting the broad lobe-like pseudopodia of *Amœba*, have the faculty of sending out long thin threads of protoplasm, which they can again retract, and by the aid of which they capture their prey or move from place to place. Simple structureless protoplasm as they are, many of them fashion for themselves an outer membranous or calcareous case, often of symmetrical form and elaborate ornamentation, or construct a silicious skeleton of radiating spicula, or crystal clear concentric spheres of exquisite symmetry and beauty.

Some move about by the aid of a flagellum, or long whip-like projection of their bodies, by which they lash the surrounding waters, and which, unlike the pseudopodia of *Amœba*, cannot, during active life, be withdrawn into the general protoplasm of the body; while among many

has seen a relation between these and the cilia on the swarm spores of Vaucheria, where each cilium seems to be supported by a rodlet. That this condition of the cortical layer, however, is not a general feature of cell protoplasm, is certain; it is but a special case of structural differentiation. Indeed, the complex structure which has been detected in the nucleus and in the surrounding cell-protoplasm can scarcely be otherwise regarded than as an expression of an early differentiation in the structure of the cell, and not, as has been maintained, an ultimate or 'plastidular' condition of protoplasm.

others locomotion is effected by means of cilia—microscopic vibratible hairs, which are distributed in various ways over the surface, and which, like the pseudopodia and flagella, are simple prolongations of their protoplasm.

In every one of these cases the entire body has the morphological value of a cell, and in this simple cell reside the whole of the properties which manifest themselves in the vital phenomena of the organism.

The part fulfilled by these simple unicellular beings in the economy of nature has at all times been very great, and many geological formations, largely built up of their calcareous or silicious skeletons, bear testimony to the multitudes in which they must have swarmed in the waters of the ancient earth.

Those which have thus come down to us from ancient times owe their preservation to the presence of the hard persistent structures secreted by their protoplasm, and must, after all, have formed but a very small proportion of the unicellular organisms which peopled the ancient world, and there fulfilled the duties allotted to them in nature, but whose soft, perishable bodies have left no trace behind.

In our own days similar unicellular organisms are at work, taking their part silently and unobtrusively in the great scheme of creation, and mostly destined, like their predecessors, to leave behind them no record of their existence. The Red Snow Plant, to which is mainly due the beautiful phenomenon by which tracts of Arctic and Alpine snow become tinged of a delicate crimson, is a microscopic organism whose whole body consists of a simple spherical cell. In the protoplasm of this little cell must reside all the essential attributes of life; it must grow by the reception of nutriment; it must repeat by multiplication that form which it has itself inherited from its parent; it must be able to respond to the stimulus of the physical conditions by which it is surrounded. And there it is, with its structure almost on the bounds of extremest simplification, taking its allotted part in the economy of nature, combining into living matter the lifeless elements which lie around it, redeeming from sterility the regions of never-thawing ice, and peopling with its countless millions the wastes of the snow land.[3]

But organisation does not long rest on this low stage of unicellular simplicity, for as we pass from these lowest forms into higher, we find cell added to cell, until many millions of such units become associated in a single organism, where each cell, or each group of cells, has its own special work, while all combine for the welfare and unity of the whole.

In the most complex animals, however, even in man himself, the component cells, notwithstanding their frequent modification and the usual

[3] The Red Snow Plant (*Protococcus nivalis*) acts on the atmosphere through the agency of chlorophyll, like the ordinary green plants. As in these, chlorophyll is developed in it, and is only withdrawn from view by the predominant red pigment to which the *Protococcus* owes one of its most striking characteristics.

intimacy of their union, are far from losing their individuality. Examine under the microscope a drop of blood freshly taken from the human subject, or from any of the higher animals. It is seen to be composed of a multitude of red corpuscles, swimming in a nearly colourless liquid, and along with these, but in much smaller numbers, somewhat larger colourless corpuscles. The red corpuscles are modified cells, while the colourless corpuscles are cells still retaining their typical form and properties. These last are little masses of protoplasm, each enveloping a central nucleus. Watch them. They will be seen to change their shape; they will project and withdraw pseudopodia, and creep about like an *Amœba*. But, more than this, like an *Amœba*, they will take in solid matter as nutriment. They may be fed with coloured food, which will then be seen to have accumulated in the interior of their soft transparent protoplasm; and in some cases the colourless blood-corpuscles have actually been seen to devour their more diminutive companions, the red ones.

Again, there are certain cells filled with peculiar coloured matters, and called pigment-cells, which are especially abundant, as constituents of the skin in fishes, frogs, and other low vertebrate, as well as many invertebrate animals. Under certain stimuli, such as that of light, or of emotion, these pigment cells change their form, protrude or retract pseudopodial prolongations of their protoplasm, and assume the form of stars or of irregularly lobed figures, or again draw themselves together into little globular masses. To this change of form in the pigment-cell the rapid change of colour so frequently noticed in the animals provided with them is to be attributed.

The animal egg, which in its young state forms an element in the structure of the parent organism, possesses in the relations now under consideration a peculiar interest. The egg is a true cell, consisting essentially of a lump of protoplasm enclosing a nucleus, and having a nucleolus included in the interior of the nucleus. While still very young it has no constant form, and is perpetually changing its shape. Indeed, it is often impossible to distinguish it from an *Amœba*; and it may, like an *Amœba*, wander from place to place by the aid of its pseudopodial projections. I have shown elsewhere[4] that the primitive egg of the remarkable hydroid *Myriothela* manifests amœboid motions; while Haeckel has shown[5] that in the sponges certain amœba-like organisms, which are seen wandering about in the various canals and cavities of their bodies, and had been until lately regarded as parasites which had gained access from without, are really the eggs of the sponge; and a similar amœboid condition is presented by the very young eggs of even the highest animals.

Again, Reichenbach has proved[6] that during the development of the

[4] *On the Structure and Development of Myriothela. Phil. Trans.* vol. 165, 1875, p. 552.

[5] *Jenaische Zeitschr.* 1871.

[6] *Die Embryonanloge und erste Entwickelung des Flusskrebse. Zeitschr. f. wissens. Zoologie*, 1877.

crayfish the cells of the embryo throw out pseudopodia by which, exactly as in an Amœba, the yolk-spheres which serve as nutriment for the embryo are surrounded and engulphed in the protoplasm of the cells.

I had shown some years ago[7] that in *Myriothela* pseudopodial processes are being constantly projected from the walls of the alimentary canal into its cavity. They appear as direct extensions of a layer of clear, soft homogeneous protoplasm which lies over the surface of the naked cells lining the cavity, and which I now regard as the 'Hautschicht' or cortical layer of these cells. I then suggested that the function of these pseudopodia lay in seizing, in the manner of an amœba, such alimentary matter as may be found in the contents of the canal, and applying it to the nutrition of the hydroid.

What I had thus suggested with regard to Myriothela has been since proved in certain planarian worms by Metschnikoff,[8] who has seen the cells which line the alimentary canal in these animals act like independent Amœbæ, and engulph in their protoplasm such solid nutriment as may be contained in the canal. When the Planaria was fed with colouring matter these amœboid cells became gorged with the coloured particles just as would have happened in an amœba when similarly fed.

But it is not alone in such loosely aggregated cells as those of the blood, or in the amœboid cells of the alimentary canal, or in such scattered constituents of the tissues as the pigment cells, or in cells destined for an ultimate state of freedom, as the egg, that there exists an independence. The whole complex organism is a society of cells, in which every individual cell possesses an independence, an autonomy, not at once so obvious as in the blood-cells, but not the less real. With this autonomy of each element there is at the same time a subordination of each to the whole, thus establishing a unity in the entire organism, and a concert and harmony between all the phenomena of its life.

In this society of cells each has its own work to perform, and the life of the organism is made up of the lives of its component cells. Here it is that we find most distinctly expressed the great law of the physiological division of labour. In the lowest organisms, where the whole being consists of a single cell, the performance of all the processes which constitute its life must devolve on the protoplasm of this one cell; but as we pass to more highly organised beings, the work becomes distributed among a multitude of workers. These workers are the cells which now make up the complex organism. The distribution of labour, however, is not a uniform one, and we are not to suppose that the work performed by each cell is but a repetition of that of every other. For the life processes, which are accumulated in the single cell of the unicellular organism become in the more complex organism differentiated, some being intensified and otherwise modified and allocated to special cells, or to

[7] *Loc. cit.*

[8] *Ueber die Verdauungsorgane einiger Susswasser-Turbellarien. Zoologischer Anzeiger*, December 1878.

special groups of cells, which we call organs, and whose proper duty is now to take charge of the special processes which have been assigned to them. In all this we have a true division of labour,—a division of labour, however, by no means absolute; for the processes which are essential to the life of the cell must still continue common to all the cells of the organism. No cell, however great may be the differentiation of function in the organism, can dispense with its irritability, the one constant and essential property of every living cell. There thus devolves on each cell or group of cells some special work which contributes to the well-being of all, and their combined labours secure the necessary conditions of life for every cell in the community, and result in those complex and wonderful phenomena which constitute the life of the higher organisms.

We have hitherto considered the cell only as a mass of active nucleated protoplasm, either absolutely naked, or partially enclosed in a protective case, which still permits free contact of the protoplasm with the surrounding medium. In very many instances, however, the protoplasm becomes confined within resisting walls, which entirely shut it in from all direct contact with the medium which surrounds it. With the plant this is almost always so after the earliest stages of its life. Here the protoplasm of the cells is endowed with the faculty of secreting over its surface a firm, resisting membrane, composed of cellulose, a substance destitute of nitrogen, thus totally different from the contained protoplasm, and incapable of manifesting any of the phenomena of life.

Within the walls of cellulose the protoplasm is now closely imprisoned, but we are not on that account to suppose that it has lost its activity, or has abandoned its work as a living being. Though it is now no longer in direct contact with the surrounding medium, it is not the less dependent on it, and the reaction between the imprisoned protoplasm and the outer world is still permitted by the permeability of the surrounding wall of cellulose.

When the protoplasm thus becomes surrounded by a cellulose wall it seldom retains the uniform arrangement of its parts which is often found in the naked cells. Minute cavities or vacuoles make their appearance in it; these increase in size and run one into the other, and may finally form one large cavity in the centre, which becomes filled with a watery fluid, known as the Cell Sap. This condition of the cell was the first observed, and it was it which suggested the often inapplicable term 'cell.' By the formation of this central sap cavity the surrounding protoplasm is pushed aside, and pressed against the cellulose wall, over which it now extends as a continuous layer. The nucleus either continues near the centre, enveloped by a layer of protoplasm, which is connected by radiating bands of protoplasm with that of the walls, or it accompanies the displaced protoplasm, and lies embedded in this on the walls of the cell.

We have abundant evidence to show that the imprisoned protoplasm loses none of its activity. The *Characæ* constitute an exceedingly in-

teresting group of simple plants, common in the clear water of ponds and of slowly running streams. The cells of which they are built up are comparatively large, and, like almost all vegetable cells, are each enclosed in a wall of cellulose. The cellulose is perfectly transparent, and if the microscope, even with a low power, be brought to bear on one of these cells, a portion of its protoplasm may be seen in active rotation, flowing up one side of the long tubular cell and down the other, and sweeping on with it such more solid particles as may become enveloped in its current. In another water plant, the *Valisneria spiralis*, a similar active rotation of the protoplasm may be seen in the cells of the leaf, where the continuous stream of liquid protoplasm sweeping along the green granules of chlorophyll, and even carrying the globular nucleus with it in its current, presents one of the most beautiful of the many beautiful phenomena which the microscope has revealed to us.

In many other cells with large sap-cavities, such as those which form the stinging hairs of nettles and other kinds of vegetable hairs, the protoplasmic lining of the wall may send off into the sap-cavity projecting ridges and strings, forming an irregular network, along which, under a high power of the microscope, a slow streaming of granules may be witnessed. The form and position of this protoplasmic network undergo constant changes, and the analogy with the changes of form in an *Amœba* becomes obvious. The external wall of cellulose renders it impossible for the confined protoplasm to emit, like a naked *Amœba*, pseudopodia from its outer side; but on the inner side there is no obstacle to the extension of the protoplasm, and here the cavity of the cell becomes more or less completely traversed by protoplasmic projections from the wall. These often stretch themselves out in the form of thin filaments, which, meeting with a neighbouring one, become fused into it; they show currents of granules streaming along their length, and after a time become withdrawn and disappear. The vegetable cell, in short, with its surrounding wall of cellulose, is in all essential points a closely imprisoned Rhizopod.

Further proof that the imprisoned protoplasm has lost by its imprisonment none of its essential irritability, is afforded by the fact that if the transparent cell of a Nitella, one of the simple water-plants just referred to, be touched under the microscope with the point of a blunt needle, its green protoplasm will be seen to recede, under the irritation of the needle, from the cellulose wall. If the cellulose wall of the comparatively large cell which forms the entire plant in a Vaucheria, a unicellular alga, very common in shallow ditches, be ruptured under the microscope, its protoplasm will escape, and may then be often seen to throw out pseudopodial projections and exhibit amœboid movements.

Even in the higher plants, without adducing such obvious and well-known instances as those of the Sensitive Plant and Venus's Flytrap, the irritability of the protoplasm may be easily rendered manifest. There are many herbaceous plants in which if the young succulent stem of a vigorously growing specimen receive a sharp blow, of such a nature how-

ever as not to bruise its tissues, or in any way wound it, the blow will sometimes be immediately followed by a drooping of the stem commencing at some distance above the point to which the stroke had been applied: its strength appears to have here suddenly left it, it is no longer able to bear its own weight, and seems to be dying. The protoplasm, however, of its cells, is in this instance not killed, it is only stunned by the violence of the blow, and needs time for its restoration. After remaining, it may be for some hours, in this drooping and flaccid state, the stem begins to raise itself, and soon regains its original vigour. This experiment will generally succeed well in plants with a rather large terminal spike or raceme when the stroke is applied some little distance below the inflorescence shortly before the expansion of the flower.

In the several instances now adduced the protoplasm is in the mature state of the plant entirely included within a wall of cellulose. Some recent beautiful observations, however, of Mr. Francis Darwin, have shown that even in the higher plants truly naked protoplasm may occur. From the cells of certain glandular hairs contained within the cup-like receptacles formed by the united bases of two opposite leaves in the Teazel (*Dipsacus*) he has seen emitted long pseudopodia-like projections of the protoplasm. What may be the significance of this very exceptional phenomenon is still undetermined. It is probably, as Mr. Darwin supposes, connected with the absorption of nitrogenous matter.

That there is no essential difference between the protoplasm of plants and that of animals is rendered further evident by other motor phenomena, which we are in the habit of regarding as the exclusive attribute of animals. Many of the more simply organised plants give origin to peculiar cells called 'spores,' which separate from the parent, and, like the seeds of the higher plants, are destined to repeat its form. In many cases these spores are eminently locomotive. They are then termed 'swarm-spores,' and their movements are brought about, sometimes by changes of shape, when they move about in the manner of an *Amœba*, but more frequently by minute vibratile cilia, or by more strongly developed flagella or whip-like projections of their protoplasm. These cilia and flagella are absolutely indistinguishable from similar structures widely distributed among animals, and by their vibratory or lashing strokes upon the surrounding water the swarm-spores are rapidly carried from place to place. In these motions they often present a curious semblance of volition, for if the swarm-spore meet with an obstacle in its course, it will, as if to avoid it, change the direction of its motion, and retreat by a reversion of the stroke of its cilia. They are usually attracted by light, and congregate at the light side of the vessel which contains them, though in some cases light has the opposite effect on them and they recede from it.

Another fact may here be adduced to show the uniform character of protoplasm and how very different are its properties from those of lifeless matter, namely, the faculty which all living protoplasm possesses of

resisting the entrance of colouring matter into its substance. As many here present are aware, microscopists are in the habit of using in their investigations various colouring matters, such as solutions of carmine. These act differently on the different tissues, staining some, for example, more deeply than others, and thus enabling the histologist to detect certain elements of structure, which would otherwise remain unknown. Now if a solution of carmine be brought into contact with living protoplasm, this will remain, so long as it continues alive, unaffected by the colouring matter. But if the protoplasm be killed the carmine will at once pervade its whole substance, and stain it throughout with a colour more intense than even that of the colouring solution itself.

But no more illustrative example can be offered of the properties of protoplasm as living matter, independently of any part it may take in organisation, than that presented by the Myxomycetæ.

The Myxomycetæ constitute a group of remarkable organisms, which, from their comparatively large size and their consisting, during a great part of their lives, of naked protoplasm, have afforded a fine field for research, and have become one of the chief sources from which our knowledge of the nature and phenomena of protoplasm has been derived.

They have generally been associated by botanists with the Fungi, but though their affinities with these are perhaps closer than with any other plants, they differ from them in so many points, especially in their development, as to render this association untenable. They are found in moist situations, growing on old tan or on moss, or decaying leaves or rotten wood, over which they spread in the form of a network of naked protoplasmic filaments, of a soft creamy consistence, and usually of a yellowish colour.

Under the microscope, the filaments of the network exhibit active spontaneous movements, which, in the larger branches, are visible under an ordinary lens, or even by the naked eye. A succession of undulations may then be noticed passing along the course of the threads. Under higher magnifying powers, a constant movement of granules may be seen flowing along the threads, and streaming from branch to branch of this wonderful network. Here and there offshoots of the protoplasm are projected, and again withdrawn in the manner of the pseudopodia of an *Amœba*, while the whole organism may be occasionally seen to abandon the support over which it had grown, and to creep over neighbouring surfaces, thus far resembling in all respects a colossal ramified *Amœba*. It is also curiously sensitive to light, and may be sometimes found to have retreated during the day to the dark side of the leaves, or into the recesses of the tan over which it had been growing, and again to creep out on the approach of night.

After a time there arise from the surface of this protoplasmic net oval capsules or spore-cases, in which are contained the spores or reproductive bodies of the Myxomycetæ. When the spore-case has arrived at maturity, it bursts and allows the spores to escape. These are in the form

of spherical cells, each included in a delicate membranous wall, and when they fall into water the wall becomes ruptured, and the little cell creeps out. This consists of a little mass of protoplasm with a round central nucleus, enclosing a nucleolus, and with a clear vacuole, which exhibits a rhythmically pulsating movement. The little naked spore thus set at liberty is soon seen to be drawn out at one point into a long vibratile whip-like flagellum, which by its lashing action carries the spore from place to place. After a time the flagellum disappears, and the spore may now be seen emitting and withdrawing finger-like pseudopodia, by means of which it creeps about like an *Amœba*, and like an *Amœba* devours solid particles by engulfing them in its soft protoplasm.

So far these young amœba-like Myxomycetæ have enjoyed each an independent existence. Now, however, a singular and significant phenomenon is presented. Two or more of these Myxamœbæ, as they have been called, approach one another, come into contact, and finally become completely fused together into a single mass of protoplasm, in which the components are no longer to be distinguished. To the body thus formed by the fusion of the Myxamœbæ the name of 'plasmodium' has been given.

The plasmodium continues, like the simple amœbiform bodies of which it is composed, to grow by the ingestion and assimilation of solid nutriment, which it envelopes in its substance; it throws out ramifying and inosculating processes, and finally becomes converted into a protoplasmic network, which in its turn gives rise to spore-cases with their contained spores and thus completes the cycle of its development.

Under certain external conditions the Myxomycetæ have been observed to pass from an active mobile state into a resting state, and this may occur both in the amœbiform spores and in the plasmodium. When the plasmodium is about to pass into a resting state, it usually withdraws its finer branches and expels such solid ingesta as may be included in it. Its motions then gradually cease, it breaks up into a multitude of polyhedral cells, which, however, remain connected, and the whole body dries into a horny brittle mass, known by the name of 'sclerotium.'

In this condition, without giving the slightest sign of life, the sclerotium may remain for many months. Life, however, is not destroyed, its manifestations are only suspended, and if after an indefinite time the apparently dead sclerotium be placed in water, it immediately begins to swell up, the membranous covering of its component cells becomes dissolved and disappears, and the cells themselves flow together into an active amœboid plasmodium.

We have already seen that every cell possesses an autonomy or independent individuality, and from this we should expect that, like all living beings, it had the faculty of multiplying itself, and of becoming the parent of other cells. This is truly the case, and the process of cell-multiplication has of late years been studied, with the result of adding largely to our knowledge of the phenomena of life.

The labours of Strasburger, of Auerbach, of Oscar Hertwig, of Eduard van Beneden, Bütschli, Fol, and others, here come prominently before us, but neither the time at my disposal nor the purport of this address will allow me to do more than call your attention to some of the more striking results of their investigations.

By far the most frequent mode of multiplication among cells shows itself in a spontaneous division of the protoplasm into two separate portions, which then become independent of one another, so that instead of the single parent cell two new ones have made their appearance. In this process the nucleus usually takes an important part. Strasburger has studied it with great care in certain plant-cells, such as the so-called 'corpuscula' or 'secondary embryo-sacs' of the Coniferæ and the cells of Spirogyra; and has further shown a close correspondence between cell-division in animals and that in plants.

It may be generally stated as the results of his observations on the corpuscula of the Coniferæ, that the nucleus of the cell about to divide assumes a spindle shape, and at the same time presents a peculiar striated differentiation, as if it were composed of parallel filaments reaching from end to end of the spindle. These filaments become thickened in the middle, and there form by the approximation of the thickened portions a transverse plate of protoplasm (the 'nucleus-plate'). This soon splits into two halves, which recede from one another towards the poles of the spindle, travelling in this course along the filaments, which remain continuous from end to end. When arrived near the poles they form there two new nuclei, still connected with one another by the intervening portion of the spindle.

In the equator of this intervening portion there is now formed in a similar way a second plate of protoplasm (the 'cell-plate'), which, extending to the walls of the dividing cell, cuts the whole protoplasm into two halves, each half containing one of the newly-formed nuclei. This partition plate is at first single, but it soon splits into two laminæ, which become the apposed bounding surfaces of the two protoplasm masses into which the mother cell has been divided. A wall of cellulose is then all at once secreted between them, and the two daughter cells are complete.

It sometimes happens in the generation of cells that a young brood of cells arises from the parent cell by what is called 'free cell-formation.' In this only a part of the protoplasm of the mother cell is used up in the production of the offspring. It is seen chiefly in the formation of the spores of the lower plants, in the first foundation of the embryo in the higher, and in the formation of the endosperm—a cellular mass which serves as the first nutriment for the embryo—in the seeds of most Phanerogams. The formation of the endosperm has been carefully studied by Strasburger in the embryo-sac of the kidney bean, and may serve as an example of the process of free cell-formation. The embryo-sac is morphologically a large cell with its protoplasm, nucleus, and cellulose wall, while the endosperm which arises within it is composed of a multitude of minute cells united

into a tissue. The formation of the endosperm is preceded by the dissolution and disappearance of the nucleus of the embryo-sac, and then in the midst of the protoplasm of the sac several new nuclei make their appearance. Around each of these as a centre the protoplasm of the mother cell is seen to have become differentiated in the form of a clear spherule, and we have thus corresponding to each of the new nuclei a young naked cell, which soon secretes over its surface a membrane of cellulose. The new cells, when once formed, multiply by division, press one on the other, and so combining into a cellular mass, constitute the completed endosperm.

Related to the formation of new cells, whether by division or by free cell-formation, is another very interesting phenomenon of living protoplasm known as 'rejuvenescence.' In this the whole protoplasm of a cell, by a new arrangement of its parts, assumes a new shape and acquires new properties. It then abandons its cellulose chamber, and enters on a new and independent life in the surrounding medium.

A good example of this is afforded by the formation of swarm-spores in Oedogonium, one of the fresh-water Algæ. Here the whole of the protoplasm of an adult cell contracts, and by the expulsion of its cell-sap changes from a cylindrical to a globular shape. Then one spot becomes clear, and a pencil of vibratile cilia here shows itself. The cellulose wall which had hitherto confined it now becomes ruptured, and the protoplasmic sphere, endowed with new faculties of development and with powers of active locomotion, escapes as a swarm spore, which, after enjoying for a time the free life of an animal, comes to rest, and developes itself into a new plant.

The beautiful researches which have within the last few years been made by the observers already mentioned, on the division of animal cells, show how close is the agreement between plants and animals in all the leading phenomena of cell-division, and afford one more proof of the essential unity of the two great organic kingdoms.

There is one form of cell which, in its relation to the organic world, possesses a significance beyond that of every other, namely, the egg. As already stated, the egg is, wherever it occurs, a typical cell, consisting essentially of a globule of protoplasm enveloping a nucleus (the 'germinal vesicle'), and with one or more nucleoli (the 'germinal spots') in the interior of the nucleus. This cell, distinguishable by no tangible characters from thousands of other cells, is nevertheless destined to run through a definite series of developmental changes, which have as their end the building up of an organism like that to which the egg owes its origin.

It is obvious that such complex organisms as thus result—composed, it may be, of countless millions of cells—can be derived from the simple egg cell only by a process of cell-multiplication. The birth of new cells derived from the primary cell or egg thus lies at the basis of embryonic development. It is here that the phenomena of cell-multiplication in the

animal kingdom can in general be most satisfactorily observed, and the greater number of recent researches into the nature of these phenomena have found their most fertile field in the early periods of the development of the egg.

A discussion of the still earlier changes which the egg undergoes in order to bring it into the condition in which cell-multiplication may be possible, would, however full of interest, be here out of place; and I shall therefore confine myself to the first moments of actual development—to what is called 'the cleavage of the egg'—which is nothing more than a multiplication of the egg cell by repeated division. I shall further confine myself to an account of this phenomenon as presented in typical cases, leaving out of consideration certain modifications which would only complicate and obscure our picture.

The egg, notwithstanding the preliminary changes to which I have alluded, is still, at the commencement of development, a true cell. It has its protoplasm and its nucleus, and it is, as a rule, enveloped in a delicate membrane. The protoplasm forms what is known as the vitellus, or yolk, and the surrounding membrane is called the 'vitellary membrane.' The division which is now about to take place in it is introduced by a change of form in the nucleus. This becomes elongated, and assumes the shape of a spindle, similar to what we have already seen in the cell-division of plants. On each pole of the spindle transparent protoplasm collects, forming here a clear spherical area.

At this time a very striking and characteristic phenomenon is witnessed in the egg. Each pole of the spindle has become the centre of a system of rays which stream out in all directions into the surrounding protoplasm. The protoplasm thus shows, enveloped in its mass, two sun-like figures, whose centres are connected to one another by the spindle-shaped nucleus. To this, with the sun-like rays streaming from its poles, Auerbach gives the name of 'Karyolitic figure,' suggested by its connection with the breaking up of the original nucleus, to which our attention must next be directed.

A phenomenon similar to one we have already seen in cell-division among plants now shows itself. The nucleus becomes broken up into a number of filaments, which lie together in a bundle, each filament stretching from pole to pole of the spindle. Exactly in its central point every filament shows a knot-like enlargement, and from the close approximation of the knots there results a thick zone of protoplasm in the equator of the spindle. Each knot soon divides into two halves, and each half recedes from the equator and travels along the filament towards its extremity. When arrived at the poles of the spindle each set of half-knots becomes fused together into a globular body, while the intervening portion of the spindle, becoming torn up, and gradually drawn into the substance of the two globular masses, finally disappears. And now, instead of the single fusiform nucleus whose changes we have been tracing, we have two new globular nuclei, each occupying the place of

one of its poles, and formed at its expense.[9] The egg now begins to divide along a plane at right angles to a line connecting the two nuclei. The division takes place without the formation of a cell-plate such as we saw in the division of the plant cell, and is introduced by a constriction of its protoplasm, which commences at the circumference just within the vitelline membrane, and, extending towards the centre, divides the whole mass of protoplasm into two halves, each including within it one of the new nuclei. Thus the simple cell which constituted the condition of the egg at the commencement of development becomes divided into two similar cells. This forms the first stage of cleavage. Each of these two young cells divides in its turn in a direction at right angles to the first division-plane, while by continued repetition of the same act the whole of the protoplasm or yolk becomes broken up into a vast multitude of cells, and the unicellular organism—the egg, with which we began our history—has become converted into an organism composed of many thousands of cells. This is one of the most widely distributed phenomena of the organic world. It is called 'the cleavage of the egg,' and consists essentially in the production, by division, of successive broods of cells from a single ancestral cell—the egg.

It is no part of my purpose to carry on the phenomena of development further than this. Such of my hearers as may desire to become acquainted with the further history of the embryo, I would refer to the excellent address delivered two years ago at the Plymouth meeting of the Association by one of my predecessors in this chair—Prof. Allen Thompson.

That protoplasm, however, may present a phenomenon the reverse of that in which a simple cell becomes multiplied into many, is shown by a phenomenon already referred to—the production of plasmodia in the Myxomycetæ by the fusion into one another of cells originally distinct.

The genus Myriothela will afford another example in which the formation of plasmodia becomes introduced into the cycle of development.

[9] Though none of the above-mentioned observers to whom we owe our knowledge of the phenomena here described seem to have thought of connecting the fibrous condition assumed by the spindle with any special structure of the quiescent nucleus, it is highly probable that it consists in a rearrangement of fibres already present. That this is really the case is borne out by the observations of Schleicher on the division of cartilage cells. (*Die Knorpelzelltheilung*. Arch. für Mikr. Anat. Band xvi. Heft 2. 1878.) From these it would appear that in the division of cartilage cells the investing membrane of the nucleus first becomes torn up, and then the filaments, rodlets, and granules, which, according to him, form its body, enter into a state of intense motor activity, and may be seen arranging themselves into star-like, or wreath-like, or irregular figures, while the whole nucleus, now deprived of its membrane, may wander about the cell, travelling towards one of its poles, and then towards the other; or it may at one time contract, and then again dilate, to such an extent as nearly to fill the entire cell. To this nuclear activity Streicher applies the term 'Karyokinesis.' It results in a nearly parallel arrangement of the nuclear filaments. Then these converge at their extremities and become more widely separated in the middle, so as to give to the nucleus the form of a spindle. The filaments then become fused together at each pole of the spindle, so as to form the two new nuclei, which are at first nearly homogeneous, but which afterwards become broken up into their component filaments, rods, and granules.

The primitive eggs are here, as elsewhere, true cells with nucleolated nuclei, but without any boundary membrane. They are formed in considerable numbers, but remain only for a short time separate and distinct. After this they begin to exhibit amœboid changes of shape, project pseudopodial prolongations which coalesce with those of others in their vicinity, and finally a multitude of these primitive ova become fused together into a common plasmodium, in which, as in the simple egg cell of other animals, the phenomena of development take place.

In many of the lower plants a very similar coalescence is known to take place between the protoplasmic bodies of separate cells, and constitutes the phenomenon of conjugation. Spirogyra is a genus of Algæ, consisting of long green threads common in ponds. Every thread is composed of a series of cylindrical chambers of transparent cellulose placed end to end, each containing a sac of protoplasm with a large quantity of cell-sap, and with a green band of chlorophyll wound spirally on its walls. When the threads have attained their full growth they approach one another in pairs, and lie in close proximity, parallel one to the other. A communication is then established by means of short connecting tubes between the chambers of adjacent filaments, and across the channel thus formed the whole of the protoplasm of one of the conjugating chambers passes into the cavity of the other, and then immediately fuses with the protoplasm it finds there. The single mass thus formed shapes itself into a solid oval body, known as a 'zygospore.' This now frees itself from the filament, secretes over its naked surface a new wall of cellulose, and, when placed in the conditions necessary for its development, attaches itself by one end, and then, by repeated acts of cell-division, grows into a many-celled filament like those in which it originated.

The formation of plasmodia, regarded as a coalescence and absolute fusion into one another of separate naked masses of protoplasm, is a phenomenon of great significance. It is highly probable that, notwithstanding the complete loss of individuality in the combining elements, such difference as may have been present in these will always find itself expressed in the properties of the resulting plasmodia—a fact of great importance in its bearing on the phenomena of inheritance. Recent researches, indeed, render it almost certain that fertilisation, whether in the animal or the vegetable kingdom, consists essentially in the coalescence and consequent loss of individuality of the protoplasmic contents of two cells.

In by far the greater number of plants the protoplasm of most of the cells which are exposed to the sunlight undergoes a curious and important differentiation, part of it becoming separated from the remainder in the form usually of green granules, known as chlorophyll granules. The chlorophyll granules thus consist of true protoplasm, their colour being due to the presence of a green colouring matter, which may be extracted, leaving behind the colourless protoplasmic base.

The colouring matter of chlorophyll presents under the spectroscope a very characteristic spectrum. For our knowledge of its optical properties, on which time will not now permit me to dwell, we are mainly indebted to the researches of your townsman, Dr. Sorby, who has made these the subject of a series of elaborate investigations, which have contributed largely to the advancement of an important department of physical science.

That the chlorophyll is a living substance, like the uncoloured protoplasm of the cell, is sufficiently obvious. When once formed, the chlorophyll granule may grow by intussusception of nutriment to many times its original size, and may multiply itself by division.

To the presence of chlorophyll is due one of the most striking aspects of external nature—the green colour of the vegetation which clothes the surface of the earth; and with its formation is introduced a function of fundamental importance in the economy of plants, for it is on the cells which contain this substance that devolves the faculty of decomposing carbonic acid. On this depends the assimilation of plants, a process which becomes manifest externally by the exhalation of oxygen. Now it is under the influence of light on the chlorophyll-containing cells that this evolution of oxygen is brought about. The recent observations of Draper and of Pfeffer have shown that in this action the solar spectrum is not equally effective in all its parts; that the yellow and least refrangible rays are those which act with most intensity; that the violet and other highly refrangible rays of the visible spectrum take but a very subordinate part in assimilation; and that the invisible rays which lie beyond the violet are totally inoperative.

In almost every grain of chlorophyll one or more starch granules may be seen. This starch is chemically isomeric with the cellulose cell-wall, with woody fibre, and other hard parts of plants, and is one of the most important products of assimilation. When plants whose chlorophyll contains starch are left for a sufficient time in darkness, the starch is absorbed and completely disappears; but when they are restored to the light the starch reappears in the chlorophyll of the cells.

With this dependence of assimilation on the presence of chlorophyll a new physiological division of labour is introduced into the life of plants. In the higher plants, while the work of assimilation is allocated to the chlorophyll-containing cells, that of cell division and growth devolves on another set of cells, which, lying deeper in the plant, are removed from the direct action of light, and in which chlorophyll is therefore never produced. In certain lower plants, in consequence of their simplicity of structure and the fact that all the cells are equally exposed to the influence of light, this physiological division of labour shows itself in a somewhat different fashion. Thus in some of the simple green algæ, such as *Spirogyra* and *Hydrodictyon*, assimilation takes place as in other cases during the day, while their cell division and growth takes place chiefly, if not exclusively, at night. Strasburger, in his re-

markable observations on cell divisions in *Spirogyra*, was obliged to adopt an artificial device in order to compel the *Spirogyra* to postpone the division of its cells to the morning.

Here the functions of assimilation and growth devolve on one and the same cell, but while one of these functions is exercised only during the day, the time for the other is the night. It seems impossible for the same cell at the same time to exercise both functions, and these are here accordingly divided between different periods of the twenty-four hours.

The action of chlorophyll in bringing about the decomposition of carbonic acid is not, as was recently believed, absolutely confined to plants. In some of the lower animals, such as *Stentor* and other infusoria, the Green Hydra, and certain green planariæ and other worms, chlorophyll is differentiated in their protoplasm, and probably always acts here under the influence of light exactly as in plants.

Indeed, it has been proved[10] by some recent researches of Mr. Geddes, that the green planarias when placed in water and exposed to the sunlight give out bubbles of gas which contain from 44 to 55 per cent. of oxygen. Mr. Geddes has further shown that these animals contain granules of starch in their tissues, and in this fact we have another striking point of resemblance between them and plants.

A similar approximation of the two organic kingdoms has been shown by the beautiful researches of Mr. Darwin—confirmed and extended by his son, Mr. Francis Darwin—on Drosera and other so-called carnivorous plants. These researches, as is now well known, have shown that in all carnivorous plants there is a mechanism fitted for the capture of living prey, and that the animal matter of the prey is absorbed by the plant after having been digested by a secretion which acts like the gastric juice of animals.

Again, Nägeli has recently shown[11] that the cell of the yeast fungus contains about 2 per cent. of peptine, a substance hitherto known only as a product of the digestion of azotised matter by animals.

Indeed, all recent research has been bringing out in a more and more decisive manner the fact that there is no dualism in life,—that the life of the animal and the life of the plant are, like their protoplasm, in all essential points identical.

But there is, perhaps, nothing which shows more strikingly the identity of the protoplasm in plants and animals, and the absence of any deep-pervading difference between the life of the animal and that of the plant, than the fact that plants may be placed, just like animals, under the influence of anæsthetics.

When the vapour of chloroform or of ether is inhaled by the human subject, it passes into the lungs, where it is absorbed by the blood, and

[10] 'Sur la fonction de la chlorophyll dans les planaires vertes.' *Comptes Rendus*, December 1878.

[11] *Ueber die chemische Zusammensetzung der Hefe. Sitzungsbericht der Math. Phys. Classe der k.k. Akad. der Wissens. zu München.* 1878.

thence carried by the circulation to all the tissues of the body. The first to be affected by it is the delicate nervous element of the brain, and loss of consciousness is the result. If the action of the anæsthetic be continued, all the other tissues are in their turn attacked by it and their irritability arrested. A set of phenomena entirely parallel to these may be presented by plants.

We owe to Claude Bernard a series of interesting and most instructive experiments on the action of ether and chloroform on plants. He exposed to the vapour of ether a healthy and vigorous sensitive plant, by confining it under a bell-glass into which he introduced a sponge filled with ether. At the end of half an hour the plant was in a state of anæsthesia, all its leaflets remained fully extended, but they showed no tendency to shrink when touched. It was then withdrawn from the influence of the ether, when it gradually recovered its irritability, and finally responded, as before, to the touch.

It is obvious that the irritability of the protoplasm was here arrested by the anæsthetic, so that the plant became unable to give a response to the action of an external stimulus.

It is not, however, the irritability of the protoplasm of only the motor elements of plants that anæsthetics are capable of arresting. These may act also on the protoplasm of those cells whose function lies in chemical synthesis, such as is manifested in the phenomena of the germination of the seed and in nutrition generally, and Claude Bernard has shown that germination is suspended by the action of ether or chloroform.

Seeds of cress, a plant whose germination is very rapid, were placed in conditions favourable to a speedy germination, and while thus placed were exposed to the vapour of ether. The germination, which would otherwise have shown itself by the next day, was arrested. For five or six days the seeds were kept under the influence of the ether, and showed during this time no disposition to germinate. They were not killed, however, they only slept, for on the substitution of common air for the etherised air with which they had been surrounded, germination at once set in and proceeded with activity.

Experiments were also made on that function of plants by which they absorb carbonic acid and exhale oxygen, and which, as we have already seen, is carried on through the agency of the green protoplasm or chlorophyll, under the influence of light—a function which is commonly, but erroneously, called the respiration of plants.

Aquatic plants afford the most convenient subjects for such experiments. If one of these be placed in a jar of water holding ether or chloroform in solution, and a bell-glass be placed over the submerged plant, we shall find that the plant no longer absorbs carbonic acid or emits oxygen. It remains, however, quite green and healthy. In order to awaken the plant, it is only necessary to place it in non-etherised water, when it will begin once more to absorb carbonic acid, and exhale oxygen under the influence of sunlight.

The same great physiologist has also investigated the action of anæsthetics on fermentation. It is well known that alcoholic fermentation is due to the presence of a minute fungus, the yeast fungus, the living protoplasm of whose cells has the property of separating solutions of sugar into alcohol, which remains in the liquid, and carbonic acid, which escapes into the air.

Now, if the yeast plant be placed along with sugar in etherised water it will no longer act as a ferment. It is anæsthesiated, and cannot respond to the stimulus which, under ordinary circumstances, it would find in the presence of the sugar. If, now, it be placed on a filter, and the ether washed completely away, it will, on restoration to a saccharine liquid, soon resume its duty of separating the sugar into alcohol and carbonic acid.

Claude Bernard has further called attention to a very significant fact which is observable in this experiment. While the proper alcoholic fermentation is entirely arrested by the etherisation of the yeast plant, there still goes on in the saccharine solution a curious chemical change, the cane sugar of the solution being converted into grape sugar, a substance identical in its chemical composition with the cane sugar, but different in its molecular constitution. Now it is well known from the researches of Bertholet that this conversion of cane sugar into grape sugar is due to a peculiar inversive ferment, which, while it accompanies the living yeast plant, is itself soluble and destitute of life. Indeed it has been shown that in its natural conditions the yeast fungus is unable of itself to assimilate cane sugar, and that in order that this may be brought into a state fitted for the nutrition of the fungus, it must be first digested and converted into grape sugar, exactly as happens in our own digestive organs. To quote Claude Bernard's graphic account:—

'The fungus ferment has thus beside it in the same yeast a sort of servant given by nature to effect this digestion. The servant is the unorganised inversive ferment. This ferment is soluble, and as it is not a plant, but an unorganised body destitute of sensibility, it has not gone to sleep under the action of the ether, and thus continues to fulfil its task.'

In the experiment already recorded on the germination of seeds the interest is by no means confined to that which attaches itself to the arrest of the organising functions of the seed, those namely which manifest themselves in the development of the radicle and plumule and other organs of the young plant. Another phenomenon of great significance becomes at the same time apparent—the anæsthetic exerts no action on the concomitant chemical phenomena which in germinating seeds show themselves in the transformation of starch into sugar under the influence of diastase (a soluble and non-living ferment which also exists in the seed), and the absorption of oxygen with the exhalation of carbonic acid. These go on as usual, the anæsthesiated seed continuing to respire, as proved by the accumulation of carbonic acid in the surrounding air. The presence of the carbonic acid was rendered evident by placing in the same vessel

with the seeds which were the object of the experiment a solution of barytes, when the carbonate became precipitated from the solution in quantity equal to that produced in a similar experiment with seeds germinating in unetherised air.

So, also, in the experiment which proves that the faculty possessed by the chlorophyllian cells of absorbing carbonic acid and exhaling oxygen under the influence of light may be arrested by anæsthetics, it could be seen that the plant, while in a state of anæsthesia, continued to respire in the manner of animals: that is, it continued to absorb oxygen and exhale carbonic acid. This is the true respiratory function which was previously masked by the predominant function of assimilation, which devolves on the green cells of plants, and which manifests itself under the influence of light in the absorption of carbonic acid and the exhalation of oxygen.

It must not, however, be supposed that the respiration of plants is entirely independent of life. The conditions which bring the oxygen of the air and the combustible matter of the respiring plant into such relations as may allow them to act on one another are still under its control, and we must conclude that in Claude Bernard's experiment the anæsthesia had not been carried so far as to arrest such properties of the living tissues as are needed for this.

The quite recent researches of Schützenberger, who has investigated the process of respiration as it takes place in the cell of the yeast fungus, have shown that vitality is a factor in this process. He has shown that fresh yeast, placed in water, breathes like an aquatic animal, disengaging carbonic acid, and causing the oxygen contained in the water to disappear. That this phenomenon is a function of the living cell is proved by the fact that, if the yeast be first heated to 60° C. and then placed in the oxygenated water, the quantity of oxygen in the water remains unchanged; in other words, the yeast ceases to breathe.

Schützenberger has further shown that light exerts no influence on the respiration of the yeast cell—that the absorption of oxygen by the cell takes place in the dark exactly as in sunlight. On the other hand, the influence of temperature is well marked. Respiration is almost entirely arrested at temperatures below 10° C., it reaches its maximum at about 40° C., while at 60° C. it again ceases.

All this proves that the respiration of living beings is identical, whether manifested in the plant or in the animal. It is essentially a destructive phenomenon—as much so as the burning of a piece of charcoal in the open air, and, like it, is characterised by the disappearance of oxygen and the formation of carbonic acid.

One of the most valuable results of the recent careful application of the experimental method of research to the life phenomena of plants is thus the complete demolition of the supposed antagonism between respiration in plants and that in animals.

I have thus endeavoured to give you in a few broad outlines a sketch

of the nature and properties of one special modification of matter, which will yield to none other in the interest which attaches to its study, and in the importance of the part allocated to it in the economy of nature. Did the occasion permit I might have entered into many details which I have left untouched; but enough has been said to convince you that in protoplasm we find the only form of matter in which life can manifest itself; and that, though the outer conditions of life—heat, air, water, food—may all be present, protoplasm would still be needed, in order that these conditions may be utilised, in order that the energy of lifeless nature may be converted into that of the countless multitudes of animal and vegetable forms which dwell upon the surface of the earth or people the great depths of its seas.

We are thus led to the conception of an essential unity in the two great kingdoms of organic Nature—a structural unity, in the fact that every living being has protoplasm as the essential matter of every living element of its structure; and a physiological unity, in the universal attribute of irritability which has its seat in this same protoplasm, and is the prime mover of every phenomenon of life.

We have seen how little mere form has to do with the essential properties of protoplasm. This may shape itself into cells, and the cells may combine into organs in ever-increasing complexity, and protoplasm force may be thus intensified, and, by the mechanism of organisation, turned to the best possible account; but we must still go back to protoplasm as a naked formless plasma if we would find—freed from all non-essential complications—the agent to which has been assigned the duty of building up structure and of transforming the energy of lifeless matter into that of living.

To suppose, however, that all protoplasm is identical where no difference cognisable by any means at our disposal can be detected would be an error. Of two particles of protoplasm, between which we may defy all the power of the microscope, all the resources of the laboratory, to detect a difference, one can develope only to a jelly-fish, the other only to a man, and one conclusion alone is here possible—that deep within them there must be a fundamental difference which thus determines their inevitable destiny, but of which we know nothing, and can assert nothing beyond the statement that it must depend on their hidden molecular constitution.

In the molecular condition of protoplasm there is probably as much complexity as in the disposition of organs in the most highly differentiated organisms; and between two masses of protoplasm indistinguishable from one another there may be as much molecular difference as there is between the form and arrangement of organs in the most widely separated animals or plants.

Herein lies the many-sidedness of protoplasm; herein lies its significance as the basis of all morphological expression, as the agent of

all physiological work, while in all this there must be an adaptiveness to purpose as great as any claimed for the most complicated organism.

From the facts which have been now brought to your notice there is but one legitimate conclusion—that life is a property of protoplasm. In this assertion there is nothing that need startle us. The essential phenomena of living beings are not so widely separated from the phenomena of lifeless matter as to render it impossible to recognise an analogy between them: for even irritability, the one grand character of all living beings, is not more difficult to be conceived of as a property of matter than the physical phenomena of radial energy.

It is quite true that between lifeless and living matter there is a vast difference, a difference greater far than any which can be found between the most diverse manifestations of lifeless matter. Though the refined synthesis of modern chemistry may have succeeded in forming a few principles which until lately had been deemed the proper product of vitality, the fact still remains that no one has ever yet built up one particle of living matter out of lifeless elements—that every living creature, from the simplest dweller on the confines of organisation up to the highest and most complex organism, has its origin in pre-existent living matter—that the protoplasm of to-day is but the continuation of the protoplasm of other ages, handed down to us through periods of indefinable and indeterminable time.

Yet with all this, vast as the differences may be, there is nothing which precludes a comparison of the properties of living matter with those of lifeless.

When, however, we say that life is a property of protoplasm, we assert as much as we are justified in doing. Here we stand upon the boundary between life in its proper conception, as a group of phenomena having irritability as their common bond, and that other and higher group of phenomena which we designate as consciousness or thought, and which, however intimately connected with those of life, are yet essentially distinct from them.

When the heart of a recently killed frog is separated from its body and touched with the point of a needle, it begins to beat under the excitation of the stimulus, and we believe ourselves justified in referring the contraction of the cardiac fibres to the irritability of their protoplasm as its proper cause. We see in it a remarkable phenomenon, but one nevertheless in which we can see unmistakable analogies with phenomena purely physical. There is no greater difficulty in conceiving of contractility as a property of protoplasm than there is in conceiving of attraction as a property of the magnet.

When a thought passes through the mind, it is associated, as we have now abundant reason for believing, with some change in the protoplasm of the cerebral cells. Are we, therefore, justified in regarding thought as a property of the protoplasm of these cells, in the sense in which we

regard muscular contraction as a property of the protoplasm of muscle? or is it really a property residing in something far different, but which may yet need for its manifestation the activity of cerebral protoplasm?

If we could see any analogy between thought and any one of the admitted phenomena of matter, we should be bound to accept the first of these conclusions as the simplest, and as affording a hypothesis most in accordance with the comprehensiveness of natural laws; but between thought and the physical phenomena of matter there is not only no analogy, but there is no conceivable analogy; and the obvious and continuous path which we have hitherto followed up in our reasonings from the phenomena of lifeless matter through those of living matter here comes suddenly to an end. The chasm between unconscious life and thought is deep and impassable, and no transitional phenomena can be found by which as by a bridge we may span it over; for even from irritability, to which, on a superficial view, consciousness may seem related, it is as absolutely distinct as it is from any of the ordinary phenomena of matter.

It has been argued that because physiological activity must be a property of every living cell, psychical activity must be equally so, and the language of the metaphysician has been carried into biology, and the 'cell soul' spoken of as a conception inseparable from that of life.

That psychical phenomena however, characterised as they essentially are by consciousness, are not necessarily coextensive with those of life, there cannot be a doubt. How far back in the scale of life consciousness may exist we have as yet no means of determining, nor is it necessary for our argument that we should. Certain it is that many things, to all appearance the result of volition, are capable of being explained as absolutely unconscious acts; and when the swimming swarm-spore of an alga avoids collision, and by a reversal of the stroke of its cilia backs from an obstacle lying in its course, there is almost certainly in all this nothing but a purely unconscious act. It is but a case in which we find expressed the great law of the adaptation of living beings to the conditions which surround them. The irritability of the protoplasm of the ciliated spore responding to an external stimulus sets in motion a mechanism derived by inheritance from its ancestors, and whose parts are correlated to a common end—the preservation of the individual.

But even admitting that every living cell were a conscious and thinking being, are we therefore justified in asserting that its consciousness like its irritability is a property of the matter of which it is composed? The sole argument on which this view is made to rest is that from analogy. It is argued that because the life phenomena, which are invariably found in the cell, must be regarded as a property of the cell, the phenomena of consciousness by which they are accompanied must be also so regarded. The weak point in the argument is the absence of all analogy between the things compared, and as the conclusion rests solely on the argument from analogy, the two must fall to the ground together.

In a lecture[12] to which I once had the pleasure of listening—a lecture characterised no less by lucid exposition than by the fascinating form in which its facts were presented to the hearers, Professor Huxley argues that no difference, however great, between the phenomena of living matter and those of the lifeless elements of which this matter is composed should militate against our attributing to protoplasm the phenomena of life as properties essentially inherent in it; since we know that the result of a chemical combination of physical elements may exhibit physical properties totally different from those of the elements combined; the physical phenomena presented by water, for example, having no resemblance to those of its combining elements oxygen and hydrogen.

I believe that Professor Huxley intended to apply this argument only to the phenomena of life in the stricter sense of the word. As such it is conclusive. But if it be pushed further, and extended to the phenomena of consciousness, it loses all its force. The analogy, perfectly valid in the former case, here fails. The properties of the chemical compound are like those of its components, still physical properties. They come within the wide category of the universally accepted properties of matter, while those of consciousness belong to a category absolutely distinct—one which presents not a trace of a connection with any of those which physicists have agreed in assigning to matter as its proper characteristics. The argument thus breaks down, for its force depends on analogy alone, and here all analogy vanishes.

That consciousness is never manifested except in the presence of cerebral matter or of something like it, there cannot be a question; but this is a very different thing from its being a property of such matter in the sense in which polarity is a property of the magnet, or irritability of protoplasm. The generation of the rays which lie invisible beyond the violet in the spectrum of the sun cannot be regarded as a property of the medium which by changing their refrangibility can alone render them apparent.

I know that there is a special charm in those broad generalisations which would refer many very different phenomena to a common source. But in this very charm there is undoubtedly a danger, and we must be all the more careful lest it should exert an influence in arresting the progress of truth, just as at an earlier period traditional beliefs exerted an authority from which the mind but slowly and with difficulty succeeded in emancipating itself.

But have we, it may be asked, made in all this one step forward towards an explanation of the phenomena of consciousness or the discovery of its source? Assuredly not. The power of conceiving of a substance different from that of matter is still beyond the limits of human intelligence, and the physical or objective conditions which are the concomitants of thought are the only ones of which it is possible to know anything, and the only ones whose study is of value.

[12] 'The Physical Basis of Life.' See *Essays and Reviews*, by T. H. Huxley.

We are not, however, on that account forced to the conclusion that there is nothing in the universe but matter and force. The simplest physical law is absolutely inconceivable by the highest of the brutes, and no one would be justified in assuming that man had already attained the limit of his powers. Whatever may be that mysterious bond which connects organisation with psychical endowments, the one grand fact—a fact of inestimable importance—stands out clear and freed from all obscurity and doubt, that from the first dawn of intelligence there is with every advance in organisation a corresponding advance in mind. Mind as well as body is thus travelling onwards through higher and still higher phases; the great law of Evolution is shaping the destiny of our race; and though now we may at most but indicate some weak point in the generalisation which would refer consciousness as well as life to a common material source, who can say that in the far off future there may not yet be evolved other and higher faculties from which light may stream in upon the darkness, and reveal to man the great mystery of Thought?

REPORTS

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Report of the Committee, consisting of Professor Sir WILLIAM THOMSON, Professor CLERK MAXWELL, Professor TAIT, Dr. C. W. SIEMENS, Mr. F. J. BRAMWELL, *and* Mr. J. T. BOTTOMLEY, *for commencing Secular Experiments upon the Elasticity of Wires. Drawn up by* J. T. BOTTOMLEY.

AT the last meeting of the British Association, the arrangements for suspending wires for secular experiments in the tube which has been erected in the tower of the Glasgow University Buildings, and for observing these wires, were described and reported as complete. Some improvements have since been found necessary; but, so far as these are concerned, there is not much to add to the report then given.

The long iron tube has been closed at the top and bottom so as to keep out currents of air and dust, and the joints of the tube have been carefully caulked.

Some improvements in the cathetometer used for observing the marks on the wires were also found to be required, but the instrument is now satisfactory.

Six wires have now been suspended in the tube; their stretching weights have been attached to them, and they have been carefully marked and measured. These wires are suspended in pairs—two of gold, two of platinum, and two of palladium. One of each of the pairs is loaded with a weight equal to one-twentieth of its breaking weight, and the other of each pair with a weight equal to one-half of its breaking weight. The points of suspension for each pair are very close together, so that any yielding of the place of support affects both wires equally.

Each wire is marked with paint marks, and there are other marks on the wires and on the weights attached to them where positions have been determined. These marks are described in a laboratory book which is at present kept in the room of the Professor of Natural Philosophy in the University of Glasgow. The measurements that have been made, and the experiments that have been undertaken in connection with the work assigned to the Committee, are all being entered in this book. This,

however, can only be regarded as a temporary mode of keeping these records.

It is intended that the record in this book shall contain—

1. Description of the tube and arrangements for suspending the wires, and for suspending additional wires at future times, and description of the mode of attachment of the stretching weights.

2. Description of the cathetometer and method of measuring the changes, should there be any, in the lengths of the wires.

3. Description of the wires themselves, and record of experiments that have already been made on them as to breaking weight and Young's Modulus of Elasticity.

4. Description of the marks put on the wires, and record of the measurements that have been made as to the lengths of the wires and as to the relative positions of the marks at the time of suspending the wires.

The stretching weights and the clamps attached to the wires are engraved each with the amount of its weight in grammes. The measurements are all made in grammes and centimetres.

It seems desirable, considering the nature of the experiments that are just now commencing, that information regarding them should be preserved to the British Association in some appropriate way; and that provision should be made for recording every change that may take place, and for communicating from time to time to the Association such information as may be obtained.

In the report presented to the Association by this Committee last year, it was mentioned that experiments had been commenced in the laboratory of the University of Glasgow in connection with the present investigation on the effects of stress maintained for a considerable time in altering the elastic properties of various wires. These experiments are still being carried on, and results of interest and importance have been already arrived at.

The most important of these experiments form a series that have been made on the elastic properties of very soft iron wire. The wire used was drawn for the purpose, and is extremely soft and very uniform. It is about No. 20 B.W.G., and its breaking weight, tested in the ordinary way, is about 45 lbs. This wire has been hung up in lengths of about 20 feet, and broken by weights applied, the breaking being performed more or less slowly.

In the first place, some experiments have been tried as to the smallest weight which, applied very cautiously and with precautions against letting the weight run down with sensible velocity, will break the wire. These experiments have not yet been very satisfactorily carried out, but it is intended to complete them.

The other experiments have been carried out in the following way:—It was found that a weight of 28 lbs. does not give permanent elongation to the wire taken as it was supplied by the wire-drawer. Each length of the wire, therefore, as soon as it was hung up for experiment, was weighted with 28 lbs., and this weight was left hanging on the wire for 24 hours. Weights were then added till the wire broke, measurements as to elongation being taken at the same time. A large number of wires were broken with equal additions of weight, a pound at a time, at intervals of from three to five minutes—care being taken in all cases, however, not to add fresh weight if the wire could be seen to be running down under the effect of the weight last added. Some were broken with weights added at

the rate of one pound per day, some with three quarters of a pound per day, and some with half a pound per day. One experiment was commenced in which it was intended to break the wire at a very much slower rate than any of these. It was carried on for some months, but the wire unfortunately rusted, and broke at a place which was seen to be very much eaten away by rust, and with a very low breaking weight. A fresh wire has been suspended, and is now being tested. It has been painted with oil, and has now been under experiment for several months.

The following tables will show the general results of these experiments. It will be seen, in the first place, that the prolonged application of stress has a very remarkable effect in increasing the strength of soft iron wire. Comparing the breaking weights for the wire quickly broken with those for the same wire slowly broken, it will be seen that in the latter case the strength of the wire is from two to ten per cent. higher than in the former, and is on the average about five or six per cent. higher. The result as to elongation is even more remarkable, and was certainly more unexpected. It will seen from the tables that, in the case of the wire quickly drawn out, the elongation is on the average more than three times as great as in the case of the wire drawn out slowly. There are two wires for which the breaking weights and elongations are given in the tables, both of them 'bright' wires, which showed this difference very remarkably. They broke without showing any special peculiarity as to breaking weight, and without known difference as to treatment, except in the time during which the application of the breaking weight was made. One of them broke with 44¼ lbs., the experiment lasting one hour and a-half; the other with 47 lbs., the time occupied in applying the weight being thirty-nine days. The former was drawn out by 28·5 per cent. on its original length, the latter by only 4·79 per cent.

Tables showing the Breaking of Soft Iron Wires[1] *at Different Speeds.*

I.—Wire Quickly Broken.

Rate of Adding Weight	Breaking Weight in Pounds	Per cent. of Elongation on Original Length
*Dark Wire.		
½ lb. per minute	45	25·4
1 lb. „ 5 minutes	45¼	25·9
„ „ 5 „	45¼	24·9
„ „ 4 „	44¼	24·58
„ „ 3 „	44¼	24·88
„ „ 3 „	45¼	29·58
„ „ 5 „	44¼	27·78
*Bright Wire.		
1 lb. per 5 minutes	44¼	28·5
„ „ 5 „	44¼	27·0
„ „ 4 „	44¼	27·1

[1] The wire used was all of the same quality and gauge, but the 'dark' and 'bright' wire had gone through slightly different processes for the purpose of annealing.

II.—Wire Slowly Broken.

Weight added and No. of Experiment		Breaking Weight in Pounds	Per cent. of Elongation on Original Length
1 lb. per day.	I.	48	7·58
,,	II.	46	8·13
,,	III.	47	7·05
,,	IV.	47	6·51
,,	V.	47	8·62
,,	VI.	47	5·17
,,	VII.	46	5·50
,,	VIII.	47	6·92 Bright Wire.
¾ lb. per day.	I.	49	8·50
,,	II.	48¼	8·81
,,	III.	Broken by accident.	
,,	IV.	46	7·55
,,	V.	46	6·41
,,	VI.	45½	6·62
½ lb. per day	I.	48	8·26
,,	II.	50	8·42
,,	III.	49	7·18
,,	IV.	47	4·79 } Bright Wires.
,,	V.	46½	6·00 }

It is found during the breaking of these wires that the wire becomes alternately more yielding and less yielding to stress applied. Thus, from weights applied gradually between 28 lbs. and 31 or 32 lbs., there is very little yielding and very little elongation of the wire. For equal additions of weight between 33 lbs. and about 37 lbs. the elongation is very great. After 37 lbs. have been put on, the wire seems to get stiff again, till a weight of about 40 lbs. has been applied. Then there is rapid running down till 45 lbs. has been reached. The wire then becomes stiff again, and often remains so till it breaks.

It is evident that this subject requires careful investigation.

Fourth Report of the Committee, consisting of Dr. Joule, Professor Sir William Thomson, Professor Tait, Professor Balfour Stewart, and Professor J. Clerk Maxwell, *appointed for the purpose of effecting the Determination of the Mechanical Equivalent of Heat.*

There is little to be reported by the Committee this year, the work at present in progress being the protracted one for supplying the means of correcting errors in the determination of temperature arising from temporary changes of the fixed points of thermometers constructed of glass. The Committee have learned with pleasure that an extensive series of experiments has recently been made by Professor Henry A. Rowland, of Baltimore, who, being unaware of what had been done by the Committee, has arrived at an equivalent almost identical with that determined by Dr. Joule.

Report of the Committee appointed for the purpose of endeavouring to procure Reports on the Progress of the Chief Branches of Mathematics and Physics; the Committee consisting of Professor G. Carey Foster (*Secretary*), Professor W. G. Adams, Professor R. B. Clifton, Professor Cayley, Professor J. D. Everett, Professor Clerk Maxwell, Lord Rayleigh, Professor G. G. Stokes, Professor Balfour Stewart, Mr. Spottiswoode, *and* Professor P. G. Tait.

Owing to unforeseen circumstances only one meeting of this Committee has taken place during the past year. It seems desirable, nevertheless, in order that the question of the reappointment of the Committee may be fully considered, and that there may be a full expression of opinions on the subject referred to it, that a statement should be made to the Section of the proceedings of the Committee, the more so since, in the hope that greater progress would have been made by this time, no report was presented at the last meeting of the Association.

The first matter discussed by the Committee was the character and general plan of the reports which they should endeavour to procure; the next was to what extent or in what manner the production of such reports could be aided by the Committee. Important contributions to the discussion of these questions are contained in written communications to the Committee from two of its members—Professors Clerk Maxwell and Stokes. Professor Clerk Maxwell writes as follows:—

'Reports on special branches of science may be of several different types, corresponding to every stage of organisation, from the catalogue up to the treatise.

'When a person is engaged in scientific research, it is desirable that he should be able to ascertain, with as little labour as possible, what has been written on the subject and who are the best authorities. The ordinary method is to get hold of the most recent German paper on the subject, to look up the references there given, and by following up the trail of each to find out who are the most influential authors on the subject. German papers have the most complete references because the machinery for docketing and arranging scientific papers is more developed in Germany than elsewhere.

'The "Fortschritte der Physik" gave an annual list of all papers, good and bad, arranged in subjects, with abstracts of the more important ones. Wiedemann's "Beiblätter" is a more select assortment, given more in full.

'I think it doubtful whether a publication of this kind, if undertaken by the British Association, would succeed. Lists of the titles of the proceedings of Societies and of the contents of periodicals are given in "Nature." These are useful for strictly contemporary science, and I do not think that a more elaborate system of collection could be kept up for long.

'The intending publisher of a discovery has to examine the whole mass of science to see whether he has been anticipated, but the student wishes to read only what is worth reading. What he requires is the names of the best authors. The selection or election of these is constantly done by skimming individual authors, who indicate by the names they quote the men whose opinions have had most influence. But a report on the

history and present state of a science has for its main aim to enumerate the various authors and to point out their relative weight, and this has been very well done in several British Association Reports, some of which are nearly as old as the British Association.

'There are some branches of science whose position with respect to the public, or else to the educational interest, is such that treatises or text-books can be published on commercial principles, either as books to be read by the free public, or to be got up by the school public.

'There is little encouragement, however, for a scientific man to write a treatise so long as he can, with much less trouble, produce an original memoir, which will be much more readily received by a learned society than the treatise would have been by a publisher.

'The systematisation of science is therefore carried on under difficulties when left to itself; and I think that the experience of the British Association warrants the belief that its action in asking men of science to furnish reports has conferred benefits on science which would not otherwise have accrued to it.

'There are so many valuable reports in the published volumes that I shall indicate only a few, the selection being founded on the direction of my own work rather than on any less arbitrary principle.

'First, when a branch of science contains abstruse calculations as well as interesting experiments, it is desirable that those who cultivate the experimental side should be conscious that certain things have been done by the mathematicians. The matter to be reported on in this case is not voluminous, but it is hard reading, and those who are not experts require a guide.

'Thus, Professor Challis in 1834 gave a most useful report on the mathematical investigations by Young, Laplace, Poisson, and Gauss on Capillary Attraction, and Professor Stokes in 1862 reports on Theories of Double Refraction. This report may, indeed, be accepted as an instalment of the treatises which, if the desire of the scientific world were law, Professor Stokes would long ago have written. It is meant, no doubt, as a guide to other men's writings, but it is intelligible in itself without reference to those writings. Such a report is a full justification of the existence of the British Association, if it had done nothing else.

'Another type of report is that of Professor Cayley on Dynamics (1857 and 1862). This seems intended rather as a guide in reading the original authors than as a self-interpreting document, though, of course, besides the criticism and the methodical arrangement, there is much original light thrown on the mass of memoirs discussed in it. It will be many years before the value of this report will be superseded by treatises.

'The Report of the Committee on Mathematical Tables deals with a subject which, though not so abstruse, is larger and drier than any of the preceding. It is, however, a most interesting as well as valuable report, and supplies information which would never have been printed unless the British Association had asked for the report, and which never would have been obtained if the author of the report had not been available.

'There are several other reports which are not mere reports, but rather original papers preceded by a historical sketch of the subject. No special encouragement is needed to get people to write reports of this kind.'

Professor Stokes thus expresses himself on the subject:—

'It seems to me that reports on the progress of science may be of

two kinds, with somewhat different objects in view; and in considering the best mode of meeting these objects it may be well to keep the distinction in view.

'First, there is a report, the object of which is to prepare a sort of repertorium of what has been done in a particular branch of science since the date of the last report of similar character in the same branch of science.

'A report of this kind should present the reader with a brief account of the leading aim and chief results of the various memoirs which have been published within the time on the branch of science to which it relates; the writer should not be expected to criticise the memoirs, except in plain instances of errors or imperfections, but the responsibility of sifting the wheat from the chaff should in the main be left to the reader.

'Secondly, there are reports of a more comprehensive and far more critical character. These should be made at wider intervals, should take a more comprehensive view of the subject, and should be highly critical, sifting out the substantial acquisitions that had been made to the branch of science to which they refer.

'Each kind of reports are of value, though in somewhat different ways. The first aids the individual in keeping himself up to the progress of science around him,—a progress in which from his position he may be expected to take part and to exercise influence. They lighten to him the labour of search, but teach him to exercise his own discrimination.

'The second should be a material aid to the student in making himself master of what was really of value, and help him to avoid wasting his time on what was of little importance, and aid him in judging of the relative importance of different lines of research.

'Reports of the first kind may be much promoted by the work of committees. The division of labour lightens the task, and the feeling of co-operation carries a man through labour which otherwise, as the man is likely to have a good deal else to do, he might hesitate to undertake.

'Reports of the second kind eminently demand the hand of a master, and the hand of a master is not always free. I doubt much if the appointment of committees would aid much in the preparation of *good* reports of this class, and unless reports are thoroughly good they are better, perhaps, not attempted. I do not see what is to be done except to work a good man *when you can get him.*'

It is evident that the distinction here pointed out by Professor Stokes has an important bearing on the question of the reappointment of the Committee. The work required for the production of reports intended simply as systematic records 'of the leading aim and chief results' of published investigations, would be merely that of careful compilation. It would not only be possible to divide work of this kind among a considerable number of contributors, but to get it done at all such division of labour would be necessary, and accordingly reports of this class could only be furnished by committees. On the other hand, a report which is of the nature of a critical survey of the condition of knowledge in any branch of science, and is intended to indicate the relative value of different investigations, requires to possess a unity of plan and thought which can only result from its being the work of an individual author possessing a complete mastery of his subject. In such a case the function of the committee would be confined to the suggestion of the subject and to

requesting some qualified person to report upon it—a function which hitherto has been discharged by the Sectional Committees of the Association.

Considering all the difficulties of the undertaking and the extent to which it is rendered unnecessary by existing (chiefly German) publications, the present Committee came to the conclusion that it is not at present desirable for the Association to attempt to obtain reports in the nature of compilations of abstracts of the papers published upon mathematics or physics.

With regard to the other more critical class of reports, many have already been obtained which are recognised as among the most valuable results of the existence of the British Association; and the Committee hope for a continuance of these valuable contributions. They are happy to state that two such reports have already been promised. Professor Stokes has undertaken to draw up the plan of a report on physical optics, especially in reference to the theory of reflection, the theory of dispersion, and the theory of phosphorescence and fluorescence. Professor Balfour Stewart has also undertaken, in conjunction with Mr. J. Allan Brown, to draw up the heads of a report on terrestrial magnetism.

Twelfth Report of the Committee, consisting of Professor EVERETT, Professor Sir WILLIAM THOMSON, Professor J. CLERK MAXWELL, Mr. G. J. SYMONS, Professor RAMSAY, Professor GEIKIE, Mr. J. GLAISHER, Mr. PENGELLY, Professor EDWARD HULL, Professor ANSTED, Dr. CLEMENT LE NEVE FOSTER, Professor A. S. HERSCHEL, Mr. G. A. LEBOUR, Mr. A. B. WYNNE, Mr. GALLOWAY, Mr. JOSEPH DICKINSON, and Mr. G. F. DEACON, *appointed for the purpose of investigating the Rate of Increase of Underground Temperature downwards in various Localities of Dry Land and under Water. Drawn up by* Professor EVERETT (*Secretary*).

DR. STAPFF has forwarded to the Secretary a summary of his observations of temperature made in the St. Gothard Tunnel in 1878, in continuation of those of previous years, the places of observation being always those which have been newly opened up. At the Swiss end the portion reported on begins at 5000 and ends at 6400 metres from the north portal; and at the Italian end the limits are 4600 and 5900 metres from the south portal. In the former the temperatures (Centigrade)

25·5	26·6	27·8	27·9	28·8

were observed in the rock, at the distances from north portal (in metres)

5157	5456	5593	5725	6297

and at the depths below the surface vertically overhead (in metres)

945	971	983	1012	1250

The temperature of water was found to be higher than that of rock; whence Dr. Stapff infers the existence of hot springs in the Serpentine and the rocks immediately to the south of it.

At the Italian end, the temperatures

28·2	28·7	29·5

were found in the rock, at the distances from south portal

4830	5101	5721

and at the depths below surface vertically overhead

1407	1513	1252

In English measures, these data are as follows:—

Temperatures (Fahrenheit) at Swiss end

77°·9	79°·9	82°·0	82°·2	83°·8

Distances from north portal (in miles)

3·21	3·39	3·48	3·56	3·91

Distances below surface (in feet)

3100	3186	3225	3320	4101

Temperatures (Fahrenheit) at Italian end

82°·8	83°·7	85°·1

Distances from south portal (in miles)

3·00	3·17	3·56

Distances below surface (in feet)

4615	4965	4108

The mean rate of increase downwards in the whole length of the tunnel is ·02068 of a degree Centigrade per metre of depth, measured from the surface directly over. This is 1°F. for 88 feet. Where the surface is a steep ridge, the increase is less rapid than this average; where the surface is a valley or plain, the increase is more rapid.

The boring in connection with the Liverpool Waterworks at Bootle, which was described in last year's Report as having attained a depth of 1004 feet with a temperature of 58·1, was completed in December, the depth being 1302 feet, and the temperature at the bottom 59·0. The boring ceased for six weeks at the depth of 1004 feet, and the temperature fell during this interval from 58·1 to 57·0. The slowness of the increase downwards, and the lowness of the temperature at the bottom, are very remarkable. Mr. Symons found a temperature of 70 at the depth of only 1100 feet in the Kentish Town Well, near London; and Mr. Atkinson found a temperature of 70 at 1366 feet in the boring at South Hetton Colliery, Durham. A comparison of the temperature 59·0 at 1302 feet at Bootle with the temperature 52·0 at 226 feet gives an increase of only 7° in 1076 feet, or 1° for 154 feet.

Mr. E. Wethered, F.G.S., F.C.S., has taken during the past year a valuable series of observations at the Kingswood Collieries, near Bristol. The instrument employed was one of the Committee's slow-acting thermometers, which was inserted in holes two feet deep, bored in newly exposed coal or rock, special care being taken to avoid currents of air. As there is no explosive gas in these collieries, powerful ventilation is not necessary; and the headings in which the observations were made were ventilated by means of a square wooden pipe (called a trunk) lying on the floor, and serving for the exit of the air, while the entering air flows above and beside it. This trunk was always drawn some distance back from the end of the heading where the thermometer was inserted.

As soon as the hole for the thermometer had been bored, it was closed with clay rolled in the form of a plug, 6 inches long with a head, and the thermometer was inserted about an hour afterwards, the mouth being again closed as before. The holes were in most cases dry.

The strata in which the observations were taken belong to the lowest

of the three divisions of the Bristol coal-field, and their dip, where not faulted or disturbed, is about one in six.

The depths of the places of observation were determined by Mr. Munro, teacher of mining and surveying in the Bristol Mining School, and the surface-temperature is assumed to be identical with the mean temperature of the air for the last fifteen years at Clifton (3 miles distant), according to the observations of Dr. Burden, which is 48·7. The surface of the ground at the centre of the collieries is 24 feet higher than Dr. Burden's observatory, and is 216 feet above sea level.

The first place of observation was in an exploring drift driven at a high angle. The thermometer was placed in a hole in hard 'duns' for one week, and showed a temperature of 55·7. The depth was 441 feet, and the hole partially filled with water from natural causes. The thermometer was replaced, and after the lapse of another week the same temperature was again found.

The thermometer was next placed in a hard arenaceous stone yielding a considerable quantity of water, at practically the same depth as the last observation, and in the same drift. It gave a temperature 55·4.

Under the stone, and resting upon the duns, was a seam of coal averaging about 1 foot 6 inches thick, into which the thermometer was next inserted, and 57·2 was read at the end of another week. Illness prevented Mr. Wethered from making a re-examination to ascertain the causes of the discrepancies here exhibited, and he therefore proposes to reject these first observations.

On the abandonment of the drift just referred to, the thermometer was removed to a cross-measure branch, driven almost on a level. A week or two before, a seam of coal about 2 feet thick had been cut in this branch, and a level was now being driven on it. On Saturday, June 15, a hole was bored, at the head of the level, in the coal, and the thermometer inserted at 2 p.m., just as the men were leaving work. On Monday the temperature 54·7 was read. As the pit was idle on this day, the thermometer was replaced, and after 12 hours gave the same reading. The hole was perfectly dry, with the exception of what miners call 'sweating.'

On Saturday, June 23, the thermometer was placed in a hard blue duns at the head of the cross-measure branch, 10 feet away from the last hole; and on Monday the temperature 54·7 was taken, the same as in the coal. The pit being again idle, the observation was repeated, with a confirmatory result. The depth in each case was 402 feet.

The next observation was in the deepest workings of the collieries, in what is known as the Deep Pit colliery. A branch was being driven for the purpose of cutting off an extent of road in the Great Seam workings; accordingly on Saturday, June 29, the thermometer was placed, in the usual way, at the head of the branch in a blue duns; depth 1767 feet. On the Monday, 74·7 was read, and this temperature was confirmed by an observation from the following Saturday to Monday.

The next observation was made at a higher level in the same pit, in the Great Vein workings, depth 1367 feet. On Saturday, July 13, a hole was bored in the same bed of duns as in the last observation, and on the following Monday, 68·5 was read.

On Saturday, July 20, the thermometer was placed in the Great Seam coal, which rests upon the duns, and after the lapse of the usual time 67·5 was read.

On Saturday, July 27, by a mistake, the hole was bored in the duns 20 feet behind the coal. This point had been exposed for a week or two, and the temperature indicated, 69·2, is therefore rejected by Mr. Wethered.

On Saturday, August 3, another hole was bored in the coal, and gave on Monday the same temperature, 68·5, which had been observed in the first hole in the duns. Another hole in the duns gave, a week later, the same temperature, 68·5. Mr. Wethered adopts this as the true temperature at the depth in question (1367 feet).

The thermometer was now removed to the Speedwell pit, the shaft of which is distant about half a mile from the Deep pit, and observations were commenced in a cross-measure branch, which shortly afterwards cut the Two-feet seam of coal.

On Saturday, August 17, the thermometer was inserted in a hard arenaceous stone, and on Monday the temperature 69·7 was read, depth 1439 feet. This reading was confirmed from the following Saturday to Monday.

On Saturday, October 12, the Two-feet seam of coal having been cut, the thermometer was inserted in it, and on Monday gave a temperature of 69·7, the same as in the stone further back in the branch in August. The depth was the same within 2 feet.

On Saturday, October 26, a hole was bored in the duns under the Two-feet coal, which again gave 69·7.

The next observation was made in the Great Seam coal of the Speedwell pit, in an advanced level head, opening out new ground, depth 1232 feet. The thermometer was placed in a hole bored in the coal on Saturday, November 2, and on Monday the temperature was 66·7. The same reading was obtained the following week in the duns under the coal.

This was the last of the observations deemed reliable. Two other observations were made, the first in ground from under which coal had been worked, and the second in strata disturbed by faults, but in neither case could reliable results be obtained.

The following is a summary of the temperatures, arranged in order of depth, omitting those which are doubtful.

Depth.	Temperature. Fahrenheit
Surface	48·7
402	54·7
1232	66·7
1367	68·5
1439	69·7
1769	74·7

Comparing each depth with the next, we have the following results :—

First 402 feet	1° for 67 feet
Next 830 „	1° „ 69 „
Next 135 „	1° „ 75 „
Next 72 „	1° „ 60 „
Next 330 „	1° „ 66 „

a remarkably regular progression, especially for observations taken in different parts of a colliery. Comparing the surface with the lowest depth, we have an increase of 26°·0 in 1769 feet, which is at the rate of 1° in 68 feet; and comparing the depth of 402 feet with the lowest depth, we have an increase of 20°·0 in 1367 feet, which is at the rate of 1°·0 for 68·35 feet.

The observations appear to have been taken in very favourable circumstances, and with much care and judgment. Being the only observations yet furnished to the Committee from the West of England, they form a very valuable contribution to our knowledge.

Mr. Symons has continued his observations at the depth of 1000 feet in the Kentish Town Well (see Report for 1876, p. 209). During 1877 little was done except to continue the record of the temperature of the well-room, have the roof repaired, and make experiments with respect to the elongation of wires of various kinds. In accordance with a suggestion of Sir William Thomson, a new copper wire, No. 22, was purchased, and the Phillips's maximum thermometer, No. 14,608, of which each degree Fahr. is 0·4 inch in length, was lowered to 1000 feet on January 10, 1878. The first noticeable feature, and a very unsatisfactory one, was, that on March 5, 1878, a little mud was found in the protecting case. It will be remembered that the tube was originally 1302 feet deep, but that on the first attempt to lower the thermometer to 1100 feet in May, 1868, the cord was found to become slack at depths varying from 1070 to 1085 feet. It seems probable that the mud has now risen to 1000 feet. Its extreme softness has been illustrated more than once by the fall of thermometers into it, sometimes from a great height. They have never been broken, nor even had their indices displaced. The new wire stretched more than the old one, but after the first two months the elongation was remarkably uniform. The thermometer having been many years in use, it was thought desirable to reverify it, and on September 20, 1878, it was sent to Kew Observatory for this purpose. Another thermometer was temporarily substituted for it, which was only divided to whole degrees and was read by estimation to tenths. With this thermometer the following observations were taken :—

Date of lowering	Depth indicated	Date of raising	Depth indicated	Temperature
	Feet		Feet	Fahr.
1878, Oct. 10	1000	Nov. 2	1009	67·8
Nov. 2	1000	Dec. 2	1008	67·8
Dec. 2	1000	1879, Jan. 2	wire broke	

The wire broke on January 2, 1879, and up to the present time no serious attempt has been made to recover the thermometer, but this has arisen rather from want of leisure than from any difficulty in the operation.

The results given in the following table (which goes back to the beginning of the observations), have all been obtained with one and the same thermometer.

The index error of the thermometer has been determined several times, as follows :—

1872, August,	by Mr. Symons,	error under + ·°1
1873, November,	by Professor E. J. Mills	error + ·34
1876, February,	by Mr. Casella	„ + ·5
1878, December,	by Kew Observers	„ + ·5

The gradual rise of zero here indicated is in accordance with usual experience ; and the index errors at intermediate dates have been derived from these by graphical interpolation, that is by drawing a curve in which horizontal distance represents time and vertical distance amount of index error, the curve being drawn so as to pass through the four points determined by the above observations, and being made as smooth as possible. The stretching of the wire is determined by the readings of the

recording apparatus described in the 1869 Report, and the correction to reduce from the actual depth to the depth of 1000 feet is made by allowing ·018 of a degree per foot, this being the mean rate of increase found by observation (see Report for 1871). The above table shows that the entire range of the corrected temperatures at 1000 feet is less than half a degree, and that the departure from the mean exceeds a tenth of a degree on only seven occasions out of twenty-nine. Mr. Symons has directed close attention to those readings which differ most from the

Date of Raising	Depth Indicated	Reading of Thermometer No. 14,608	Correction for Index Error	Temperature Corrected for Index Error	Correction for Extra Depth	True Temperature at 1000 feet	Difference from Mean of all Corrected Values
	Feet	°	°	°	°	°	°
1872, December 23 .	1014	67·71	−·18	67·53	−·25	67·28	+ ·22
1873, April 5 . .	1007	67·66	·25	67·41	·13	67·28	+ ·22
July 5 . .	1009	67·58	·29	67·29	·16	67·13	+ ·07
September 5 .	1008	67·50	·32	67·18	·14	67.04	− ·02
1874, May 8 . .	1007	66·82?	—	—	—	—	
July 28 . .	1005	67·40	·42	66·98	·09	66·89	− ·17
September 8 .	1004	67·51	·43	67·08	·07	67·01	− ·05
„ 29	1004	67·43	·43	67·00	·07	66·93	− ·13
October 30 .	1006	67·68	·44	67·24	·11	67·13	+ ·07
December 3 .	1006	67·52	·45	67·07	·11	66·96	− ·10
1875, January 7 .	1009	67·63	·46	67·17	·16	67·01	− ·05
February 1 .	1006	67·56	·46	67·10	·11	66·99	− ·07
March 3 . .	1005	67·58	·46	67·12	·09	67·03	− ·03
May 3 . .	1006	67·62	·47	67·15	·11	67·04	− ·02
June 1 . .	1005	67·49	·47	67·02	·09	66·93	− ·13
July 7 . .	1005	67·53	·48	67·05	·09	66·96	− ·10
August 3 .	1004	67·58	·48	67·10	·07	67·03	− ·03
September 10	1004	67·58	·49	67·09	·07	67·02	− ·04
October 2 .	1003	67·58	·49	76·09	·05	67·04	− ·02
„ 19 .	1004	67·62	·5	67·12	·07	67·05	− ·01
November 1 .	1005	67·62	·5	67·12	·09	67·03	− ·03
1878, February 1 .	1017	67·88	·5	67·38	·31	67·07	+ ·01
March 5 . .	1012	67·77	·5	67·27	·22	67·05	− ·01
April 2 . .	1011	67·80	·5	67·30	·20	67·10	+ ·04
May 2 . .	1010	67·70	·5	67·20	·18	67·02	− ·04
June 1 . .	1008	67·63	·5	67·13	·14	66·99	− ·07
July 1 . .	1008	67·91	·5	67·41	·14	67·27	+ ·21
August 1 .	1008	67·97	·5	67·47	·14	67·33	+ ·27
September 5 .	1007	67·69	·5	67·19	·13	67·06	·00 ·00
„ 17	1008	67·68	·5	67·18	·14	67·04	− ·02
				Mean		67·06	

mean, but has not yet been able to explain the circumstances on which they depend. The maximum elongation of the wire has been 17 feet, and this gives a correction of ·31 of a degree. The gradual accumulation of mud at the bottom would account for a gradual change of temperature always in the same direction, if such had occurred (which is not the case), but will not account for alternations of rise and fall such as the table exhibits.

One of the Committee's slow-acting thermometers has been supplied (at his own expense) to Professor John A. Church, of the Ohio State

University, Columbus, Ohio, to be used for observing the temperature at every 100 feet of depth during the sinking of a shaft, probably to the depth of about 4500 feet, in one of the mines of the Comstock lode in Nevada. Two others have been supplied on similar terms to the Meteorological Office.

With the view of carrying out the resolution, expressed in last year's Report, to commence thermo-electric observations in filled bores, the Secretary has procured from Messrs. Siemens 500 feet of No. 20 copper wire, and the same length of No. 19 soft charcoal iron wire, both of them well insulated with gutta-percha, and has conducted some thermo-electric experiments with them in the Laboratory; but the apparatus is not yet ready for actual use.

Mr. Lebour has improved the form of plug devised by him (on the umbrella principle) mentioned in previous Reports (1876, p. 209, and 1877, p. 199). The apparatus now requires only one wire, and remains collapsed so long as the wire is taut, but opens out and plugs the hole when it becomes slack.

The following corrections are to be made in last year's Report.

In the acount of Dr. Stapff's thermometers, 'steel cap' and 'steel jacket,' should be 'brass cap' and 'brass jacket.'

At a later place in the extract from Dr. Stapff's paper, 'wet bore-holes with standing water,' should be 'wet bore-holes with running water.'

In the references to papers, in foot-note, '1878, 1876, and 1877,' should be '1875, 1876, and 1877.'

Report of the Committee, consisting of Professor CAYLEY, *F.R.S.*, Professor G. G. STOKES, *F.R.S.*, Professor H. J. S. SMITH, *F.R.S.*, Professor Sir WILLIAM THOMSON, *F.R.S.*, Mr. JAMES GLAISHER, *F.R.S.*, *and* Mr. J. W. L. GLAISHER, *F.R.S.* (*Secretary*), *on Mathematical Tables. Drawn up by* Mr. J. W. L. GLAISHER.

[PLATE I.]

THE present report consists of two parts: I. An account of the state of the calculation of the factor tables for the fourth, fifth, and sixth millions, with some results of the enumeration of the primes in the fourth million; and II. Tables of the Legendrian functions, with an introduction.

I.—*State of the Calculation of the Factor Tables for the Fourth, Fifth, and Sixth Millions.*

During the year the calculation has been carried on without intermission under the direction of Mr. James Glaisher. At present the factor table for the fourth million is printed and stereotyped, and will be published immediately; the manuscript of the fifth million is complete and ready for the printer. In the sixth million all the entries by sieves

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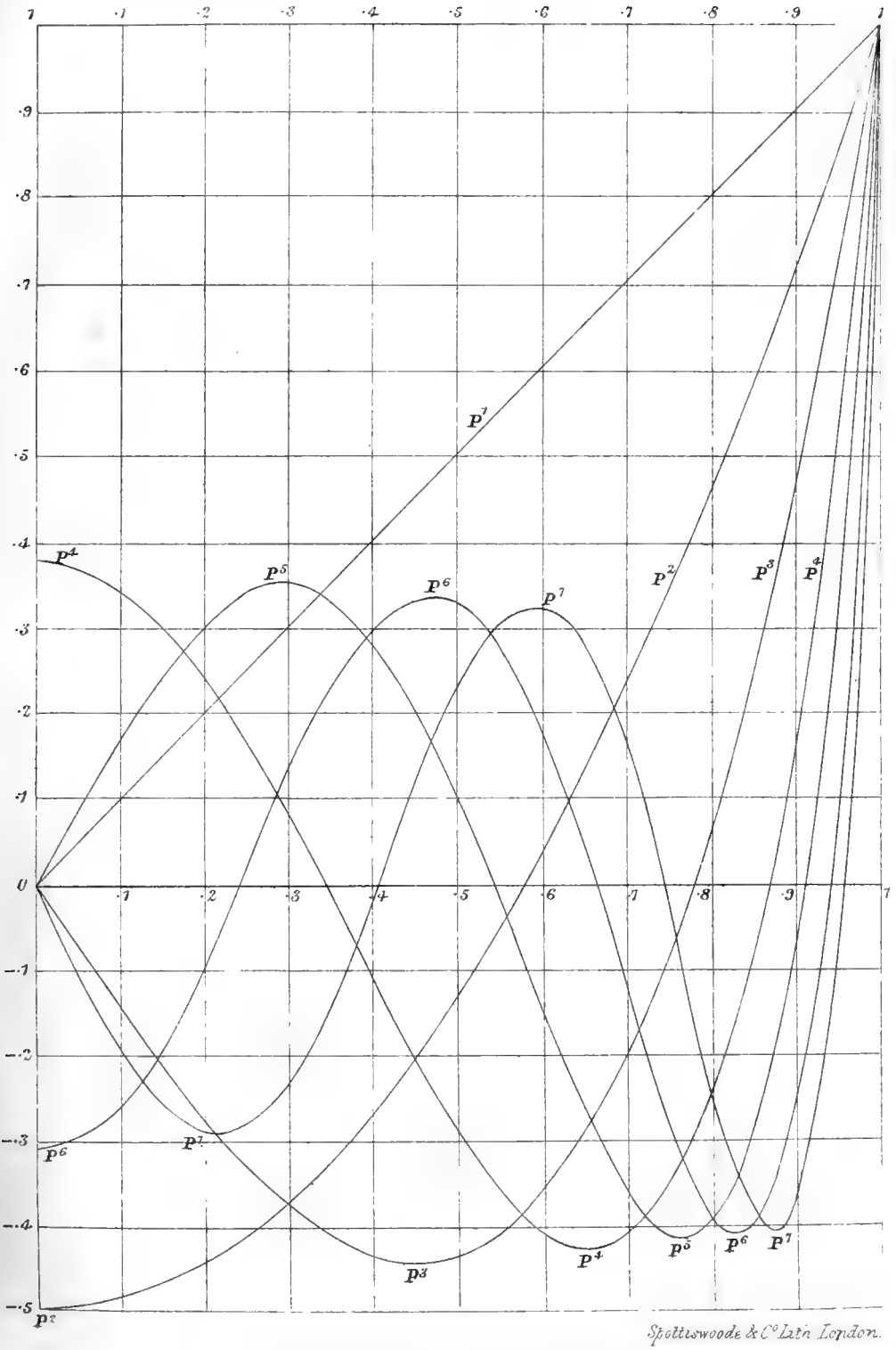

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Illustrating the Report of the Committee on Mathematical Tables.

have been made, and the factors obtained by the multiple method are in course of being entered.

The mode of construction was described in last year's report (Dublin, 1878, pp. 172–178), and a more complete account will appear in the introduction to the factor table for the fourth million.

Results of an Enumeration of the Primes in the Fourth Million.

Two independent enumerations of the primes in the fourth million were made, one from the manuscript before it was sent to the printer, and the other by a different computer from the proof sheets. The results are shown in the following table:—

3,000,000 to 4,000,000.

n	Number of centuries each of which contains n primes										
	3,000,000 to 3,100,000	3,100,000 to 3,200,000	3,200,000 to 3,300,000	3,300,000 to 3,400,000	3,400,000 to 3,500,000	3,500,000 to 3,600,000	3,600,000 to 3,700,000	3,700,000 to 3,800,000	3,800,000 to 3,900,000	3,900,000 to 4,000,000	3,000,000 to 4,000,000
0	0	1	0	0	0	0	0	0	0	1	2
1	2	3	1	4	3	4	2	3	4	4	30
2	11	13	16	13	14	12	13	17	12	15	136
3	37	31	33	50	48	42	31	43	43	42	400
4	81	87	91	85	89	89	75	77	99	89	862
5	140	146	139	133	140	156	180	146	144	156	1480
6	206	173	199	194	172	188	190	209	189	209	1929
7	183	198	193	171	216	192	178	170	169	179	1849
8	168	169	140	169	143	149	150	176	157	140	1561
9	94	96	97	102	100	102	94	83	102	80	950
10	54	52	50	51	43	35	55	52	45	60	497
11	19	19	31	23	24	24	21	21	25	14	221
12	4	9	9	5	6	3	6	3	8	7	60
13	1	2	1	0	2	3	5	0	3	2	19
14	0	1	0	0	0	1	0	0	0	2	4
No. of primes	6676	6717	6691	6639	6611	6575	6671	6590	6624	6535	66,329

The explanation of this table is as follows:—Calling, for convenience of expression, the hundred numbers between $100n - 1$ and $100\ (n + 1)$ a *century* (so that, *e.g.*, the hundred numbers between 2,999,999 and 3,000,100 form a century), then the table shows the number of centuries in each group of 100,000 which contain no prime, the number of centuries each of which contains one prime, the number of centuries each of which contains two primes, &c. Thus of the thousand centuries 3,000,000–3,100,000 no century is composed wholly of composite numbers, two centuries contain each one prime, eleven centuries contain each two primes, thirty-seven centuries contain each three primes, and so on. Of the thousand centuries 3,100,000–3,200,000, one consists wholly of composite numbers, three contain each one prime, &c.

The numbers at the foot of each column give the total number of primes in the group of numbers to which the column has reference; thus between 3,000,000 and 3,100,000 there are 6676 primes; between 3,100,000 and 3,200,000 there are 6717 primes, &c. Similar tables to the above for the first, second, third, seventh, eighth, and ninth millions have

been published in the 'Proceedings of the Cambridge Philosophical Society,' vol. iii. pp. 20–23, 54–56 (1877).

It may be remarked that in the first million there is no century consisting wholly of composite numbers, in the second there is one, in the third one, in the fourth two, in the seventh six, in the eighth four, and in the ninth four.

It will be seen from the above table that no century in the fourth million contains more than fourteen primes, and that only four contain this number. In the third million, however, there is one century containing as many as seventeen primes, one containing fifteen, and no less than six containing fourteen ; in the seventh million there are three containing fourteen primes, in the eighth million two containing fourteen, as well as two containing fifteen, and in the ninth million two containing fourteen.

The next table shows the number of primes in each successive group of ten thousand between 3,000,000 and 4,000,000. Thus, for example, between 3,000,000 and 3,010,000 there are 670 primes; between 3,010,000 and 3,020,000 there are 659, . . . ; between 3,100,000 and 3,110,000 there are 676, and so on. The numbers in the lowest line of the table are obtained by adding the numbers in each column, and agree, of course, with the numbers at the foot of the columns in the previous table.

3,000,000 to 4,000,000.

	3,000,000 to 3,100,000	3,100,000 to 3,200,000	3,200,000 to 3,300,000	3,300,000 to 3,400,000	3,400,000 to 3,500,000	3,500,000 to 3,600,000	3,600,000 to 3,700,000	3,700,000 to 3,800,000	3,800,000 to 3,900,000	3,900,000 to 4,000,000
I.	670	676	686	673	677	651	692	655	656	651
II.	659	677	674	660	666	663	670	671	682	658
III.	663	666	672	677	672	630	686	687	674	675
IV.	657	666	687	645	685	663	652	658	646	648
V.	671	658	649	675	670	654	638	649	677	678
VI.	657	677	662	623	646	668	650	667	650	643
VII.	664	668	677	688	654	670	662	632	646	638
VIII.	695	663	666	667	637	640	702	655	651	668
IX.	686	691	670	669	636	667	638	659	661	634
X.	654	675	648	662	668	669	681	657	681	642
	6676	6717	6691	6639	6611	6575	6671	6590	6624	6535

The numbers of primes in each of the seven millions are :—

	Number of Primes	Difference
First million	78,499[1]	8066
Second „	70,433	2548
Third „	67,885	1556
Fourth „	66,329	—
—	—	—
Seventh „	63,799	641
Eighth „	63,158	398
Ninth „	62,760	—

[1] 1 and 2 are counted as primes.

The numbers of primes in each quarter million in the first four millions are :—

	First Million	Second Million	Third Million	Fourth Million
First quarter . .	22,045	17,971	17,150	16,761
Second „ . .	19,494	17,682	16,991	16,573
Third „ . .	18,700	17,455	16,922	16,566
Fourth „ . .	18,260	17,325	16,822	16,429
Total . .	78,499	70,433	67,885	66,329

The following is a list of successions of composite numbers of ninety-nine and upwards occurring in the fourth million :—

SEQUENCES OF 99 AND UPWARDS.

Lower Limit	Upper Limit	Sequence
3,064,751	3,064,861	109
3,117,299	3,117,421	121
3,225,539	3,225,647	107
3,240,983	3,241,093	109
3,254,959	3,255,059	99
3,279,841	3,279,949	107
3,359,113	3,359,221	107
3,392,341	3,392,443	101
3,422,813	3,422,917	103
3,453,833	3,453,943	109
3,583,417	3,583,529	111
3,592,109	3,592,213	103
3,593,203	3,593,311	107
3,595,489	3,595,589	99
3,826,019	3,826,157	137
3,828,973	3,829,079	105
3,851,459	3,851,587	127
3,933,599	3,933,731	131

The meaning of this table is that the 109 numbers between 3,064,751 and 3,064,861 are composite, and so on—viz., the numbers in the first two columns are primes, and the numbers intermediate to the lower limit and the upper limit are all composite. The above list is not given as being necessarily complete, although it probably includes all, or very nearly all, the sequences of ninety-nine and upwards.

Similar lists of sequences for the other millions are given in the 'Messenger of Mathematics,' vol. vii. pp. 102–106; 171–176 (1877 and 1878).

It may be mentioned that the longest sequence met with in the first million was 113, in the second 131, in the third 147, in the fourth 137, in the seventh 145, in the eighth 147, and in the ninth 151.

II.—*Tables of the Legendrian Functions.*

The tables contain the values of $P^n(x)$ for $n=1, 2, 3,\ldots 7$ from $x=0$ to $x=1$, at intervals of 0·01. The functions tabulated are

$$P^0(x)=1,$$
$$P^1(x)=x,$$

$$P^2(x) = \tfrac{1}{2}(3x^2-1),$$
$$P^3(x) = \tfrac{1}{2}(5x^3-3x),$$
$$P^4(x) = \tfrac{1}{8}(35x^4-30x^2+3),$$
$$P^5(x) = \tfrac{1}{8}(63x^5-70x^3+15x),$$
$$P^6(x) = \tfrac{1}{16}(231x^6-315x^4+105x^2-5),$$
$$P^7(x) = \tfrac{1}{16}(429x^7-693x^5+315x^3-35x).$$

The functions present themselves extensively in the higher parts of mathematics (in reference to the attraction of spheroids and other physical theories [1]); but they first occur in the theory of interpolation: see Gauss, 'Methodus nova integralium valores per approximationem inveniendi' ('Comment. Gott. recent,' t. iii. pp. 39–76 (1816), or 'Werke,' t. iii. pp. 165–196), from which the numerical results given in the present introduction are taken.[2]

Suppose that y, a function of x, has to be approximately determined for the range $x = 0$ to $x = 1$, by means of the values of y corresponding to n given values of x over this range; or say that the integral $\int_0^1 y\,dx$ has to be thus determined. In the original theory, as developed by Cotes in the 'Harmonia Mensurarum' (1722), the given values of x are taken to be at equal intervals, viz., for $n = 2$, they are 0, 1; for $n = 3$, they are 0, $\frac{1}{2}$, 1; for $n = 4$, they are 0, $\frac{1}{3}$, $\frac{2}{3}$, 1, and so on.

a	Y_0	Y_a	Y_{2a}	Y_{3a}	Y_{4a}	Y_{5a}	Y_{6a}	Y_{7a}	Y_{8a}	Y_{9a}	Y_{10a}
1	$\frac{1}{2}$	$\frac{1}{2}$									
$\frac{1}{2}$	$\frac{1}{6}$	$\frac{2}{3}$	$\frac{1}{6}$								
$\frac{1}{3}$	$\frac{1}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{8}$							
$\frac{1}{4}$	$\frac{7}{90}$	$\frac{16}{45}$	$\frac{2}{15}$	$\frac{16}{45}$	$\frac{7}{90}$						
$\frac{1}{5}$	$\frac{19}{288}$	$\frac{25}{96}$	$\frac{25}{144}$	$\frac{25}{144}$	$\frac{25}{96}$	$\frac{19}{288}$					
$\frac{1}{6}$	$\frac{41}{840}$	$\frac{9}{35}$	$\frac{9}{280}$	$\frac{34}{105}$	$\frac{9}{280}$	$\frac{9}{35}$	$\frac{41}{840}$				
$\frac{1}{7}$	$\frac{751}{17280}$	$\frac{3577}{17280}$	$\frac{49}{640}$	$\frac{2989}{17280}$	$\frac{2989}{17280}$	$\frac{49}{640}$	$\frac{3577}{17280}$	$\frac{751}{17280}$			
$\frac{1}{8}$	$\frac{989}{28350}$	$\frac{2944}{14175}$	$-\frac{464}{14175}$	$\frac{5248}{14175}$	$-\frac{454}{2835}$	$\frac{5248}{14175}$	$-\frac{464}{14175}$	$\frac{2944}{14175}$	$\frac{989}{28350}$		
$\frac{1}{9}$	$\frac{2857}{89600}$	$\frac{15741}{89600}$	$\frac{27}{2240}$	$\frac{1209}{5600}$	$\frac{2889}{44800}$	$\frac{2889}{44800}$	$\frac{1209}{5600}$	$\frac{27}{2240}$	$\frac{15741}{89600}$	$\frac{2857}{89600}$	
1	16067	26575	$-\frac{16175}{199584}$	$\frac{5675}{12474}$	$-\frac{4825}{11088}$	$\frac{17807}{24948}$	$-\frac{4825}{11088}$	$\frac{5675}{12474}$	$-\frac{16175}{199584}$	$\frac{26575}{149688}$	$\frac{16067}{598752}$
10	$\frac{598752}{149688}$										

Representing y as a function of x of the order $n-1$, and determining

[1] See Todhunter's *Treatise on Laplace's Functions* (1875), Ferrers's *Treatise on Spherical Harmonics* (1877), or Heine's *Handbuch der Kugelfunctionen* (1878).

[2] A short notice of Gauss's method is given in Boole's *Finite Differences*, second edition, edited by Moulton (1872), ch. iii., art. 12, pp. 50–53.

the coefficients in this manner, we have an expression for y from which the integral $\int_0^1 y\,dx$ may be calculated. Denoting the interval by a, that is, writing $a = \frac{1}{n-1}$, the resulting formulæ, corresponding to the values $n = 2, 3, \ldots 11$ respectively, are as follows:—

Thus, for example,

$$\int_0^1 y\,dx = \tfrac{1}{2}\mathrm{Y}_0 + \tfrac{1}{2}\mathrm{Y}_1,$$
$$\text{or} \quad = \tfrac{1}{6}\mathrm{Y}_0 + \tfrac{2}{3}\mathrm{Y} + \tfrac{1}{6}\mathrm{Y}_1,$$
$$\text{or} \quad = \tfrac{1}{8}\mathrm{Y}_0 + \tfrac{3}{8}\mathrm{Y}_{\frac{1}{3}} + \tfrac{3}{8}\mathrm{Y}_{\frac{2}{3}} + \tfrac{1}{8}\mathrm{Y}_1,$$
$$\&\text{c.}, \qquad \&\text{c.}$$

In the new theory of Gauss, it is shown that it is advantageous to take the given values of x not at equal intervals, but to be the values which are the roots of the equation

$$\mathrm{P}^n(2x-1) = 0;$$

thus for $n = 1$ the value is $x = \frac{1}{2}$, for $n = 2$ the values are $\frac{1}{2} \pm \frac{1}{2\sqrt{3}}$, and so on.

The resulting formulæ are as follows:—

$$\int_0^1 y\,dx = \mathrm{A}y_a \text{ if } n = 1,$$
$$= \mathrm{A}y_a + \mathrm{A}'y_{a'} \text{ if } n = 2,$$
$$= \mathrm{A}y_a + \mathrm{A}'y_{a'} + \mathrm{A}''y_{a''} \text{ if } n = 3,$$
$$= \&\text{c.},$$

where the values of a, a'... and the coefficients A, A'... for the different values of n are

$$n = 1,$$
$$a = \tfrac{1}{2},$$
$$\mathrm{A} = 1.$$

$$\text{Approximate correction} = \frac{1}{12}\,\mathrm{L}''.^1$$

$$n = 2.$$

[1] Suppose in general the true value of y is

$$y = \mathrm{L} + \mathrm{L}'(x-\tfrac{1}{2}) + \mathrm{L}''(x-\tfrac{1}{2})^2 + \&\text{c.},$$

then the correction to be applied to $\int_0^1 y\,dx$ in the general case is

$$l^{(2n)}\mathrm{L}^{(2n)} + l^{(2n+1)}\mathrm{L}^{(2n+1)} + \&\text{c.},$$

where $l^{(m)}$ denotes the correction to be applied to $\int_0^1 (x-\frac{1}{2})^m dx$; so that $l^{(2n)}\,\mathrm{L}^{(2n)}$ may be regarded as the approximate correction to $\int_0^1 y\,dx$. Thus, for example, y being as above,

$$\int_0^1 y\,dx = \mathrm{L} + \frac{1}{12}\,\mathrm{L}'' + \frac{1}{80}\,\mathrm{L}^{\mathrm{iv}} + \frac{1}{448}\,\mathrm{L}^{\mathrm{vi}} + \&\text{c.};$$

if $n = 1$, the formula gives L, and the approximate correction $= \frac{1}{12}\mathrm{L}''$; if $n = 2$, the formula gives $\mathrm{L} + \frac{1}{12}\,\mathrm{L}'' + \frac{1}{144}\,\mathrm{L}^{\mathrm{iv}} + \&\text{c.}$, and the approximate correction

$$a,\ a' = 0{\cdot}5 \mp 0{\cdot}28867\ \ 51345\ \ 94812\ \ 9,$$
$$A = A' = \tfrac{1}{2};$$
$$\text{Approximate correction} = \frac{1}{180}\,L^{iv}.$$

$n = 3.$

$$a,\ a'' = 0{\cdot}5 \mp 0{\cdot}38729\ \ 83346\ \ 20741\ \ 7,$$
$$a' = 0{\cdot}5,$$
$$A = A'' = \tfrac{5}{18},$$
$$A' = \tfrac{4}{9};$$
$$\text{Approximate correction} = \frac{1}{2800}\,L^{vi}.$$

$n = 4.$

$$a,\ a''' = 0{\cdot}5 \mp 0{\cdot}43056\ \ 81557\ \ 97024\ \ 6,$$
$$a',\ a'' = 0{\cdot}5 \mp 0{\cdot}16999\ \ 05217\ \ 92432\ \ 3,$$
$$A = A''' = 0{\cdot}17392\ \ 74225\ \ 68728\ \ 4;\ \log = 9{\cdot}24036\ \ 80612.$$
$$A' = A'' = 0{\cdot}32607\ \ 25774\ \ 31271\ \ 6;\ \log = 9{\cdot}51331\ \ 42764.$$
$$\text{Coefficients}^1 \text{ given by } -\frac{35}{144}u^2 + \frac{17}{48};$$
$$\text{Approximate correction} = \frac{1}{44100}\,L^{viii}.$$

$n = 5.$

$$a,\ a^{iv} = 0{\cdot}5 \mp 0{\cdot}45308\ \ 99229\ \ 69332\ \ 0,$$
$$a',\ a''' = 0{\cdot}5 \mp 0{\cdot}26923\ \ 46550\ \ 52841\ \ 5,$$
$$a'' = 0{\cdot}5,$$
$$A = A^{iv} = 0{\cdot}11846\ \ 34425\ \ 28094\ \ 5;\ \log = 9{\cdot}07358\ \ 43490,$$
$$A' = A''' = 0{\cdot}23931\ \ 43352\ \ 49683\ \ 2;\ \log = 9{\cdot}37896\ \ 87142,$$
$$A'' = \frac{64}{225} = 0{\cdot}28444\ \ 44444\ \ 44444\ \ 4;\ \log = 9{\cdot}45399\ \ 74559.$$
$$\text{Coefficients, except } A'', \text{ given by } -\frac{91}{400}u^2 + \frac{1099}{3600};$$
$$\text{Approximate correction} = \frac{1}{698544}\,L^{x}.$$

$n = 6.$

$$a,\ a^{v} = 0{\cdot}5 \mp 0{\cdot}46623\ \ 47571\ \ 01576\ 0,$$
$$a',\ a^{iv} = 0{\cdot}5 \mp 0{\cdot}33060\ \ 46932\ \ 33132\ 2,$$
$$a'',\ a''' = 0{\cdot}5 \mp 0{\cdot}11930\ \ 95930\ \ 41598\ 5,$$
$$A = A^{v} = 0{\cdot}08566\ \ 22461\ \ 89585\ \ 2;\ \log = 8{\cdot}93278\ \ 94580,$$
$$A' = A^{iv} = 0{\cdot}18038\ \ 07865\ \ 24069\ \ 3;\ \log = 9{\cdot}25619\ \ 02763,$$
$$A'' = A''' = 0{\cdot}23395\ \ 69672\ \ 86345\ \ 5;\ \log = 9{\cdot}36913\ \ 59831.$$
$$\text{Coefficients given by } -\frac{77}{800}u^4 - \frac{7}{75}u^2 + \frac{23}{96};$$
$$\text{Approximate correction} = \frac{1}{11099088}\,L^{xii}.$$

$n = 7.$

$= \left(\frac{1}{80} - \frac{1}{144}\right) L^{iv} = \frac{1}{180}\ L^{iv}$; if $n = 3$, the formula gives $L + \frac{1}{12}\ L'' + \frac{1}{80}\ L^{iv} + \frac{3}{1600}\ L^{vi}$ + &c., and the approximate correction $= \left(\frac{1}{448} - \frac{3}{1600}\right) L^{vi} = \frac{1}{2800} L^{vi}$.

[1] That is to say, the coefficients A, A',... are obtained by substituting respectively the values of a, a',...for u in this formula; a similar explanation applies to the cases of $n = 5, 6, 7$.

$$\begin{aligned} a,\ a^{\mathrm{vi}} &= 0{\cdot}5 \mp 0{\cdot}47455\ \ 39561\ \ 71379\ \ 8, \\ a',\ a^{\mathrm{v}} &= 0{\cdot}5 \mp 0{\cdot}37076\ \ 55927\ \ 99697\ \ 2, \\ a'',\ a^{\mathrm{iv}} &= 0{\cdot}5 \mp 0{\cdot}20292\ \ 25756\ \ 88698\ \ 5, \\ a''' &= 0{\cdot}5, \end{aligned}$$

$$\begin{aligned} \mathrm{A} = \mathrm{A}^{\mathrm{vi}} &= 0{\cdot}06474\ \ 24830\ \ 84434\ \ 8\,;\ \log = 8{\cdot}81118\ \ 93529, \\ \mathrm{A}' = \mathrm{A}^{\mathrm{v}} &= 0{\cdot}13985\ \ 26957\ \ 44638\ \ 4\,;\ \log = 9{\cdot}14567\ \ 08421, \\ \mathrm{A}'' = \mathrm{A}^{\mathrm{iv}} &= 0{\cdot}19091\ \ 50252\ \ 52559\ \ 5\,;\ \log = 9{\cdot}28084\ \ 01093, \\ \mathrm{A}''' = \frac{256}{1225} &= 0{\cdot}20897\ \ 95918\ \ 36734\ \ 7\,;\ \log = 9{\cdot}32010\ \ 38766. \end{aligned}$$

$$\text{Coefficients, except A}''', \text{ given by } -\frac{1859}{16800}u^4 - \frac{1573}{29400}u^2 + \frac{7947}{39200};$$

$$\text{Approximate correction} = \frac{1}{176679360}\mathrm{L}^{\mathrm{xiv}}.$$

It is obvious that the foregoing formulæ give at once the roots of the equations $\mathrm{P}^n(x) = 0$, viz.,

For $n = 2$, the roots are $\pm$ 0·57735 02691 89626;

„ $n = 3$, „ „ 0 and
$\pm$ 0·77459 66692 41483;

„ $n = 4$, „ „ $\pm$ 0·33998 10435 84865,
$\pm$ 0·86113 63115 94049;

„ $n = 5$, „ „ 0 and
$\pm$ 0·53846 93101 05683,
$\pm$ 0·90617 98459 38664;

„ $n = 6$, „ „ $\pm$ 0·23861 91860 83197,
$\pm$ 0·66120 93864 66264,
$\pm$ 0·93246 95142 03152;

„ $n = 7$, „ „ 0 and
$\pm$ 0·40584 51513 77397,
$\pm$ 0·74153 11855 99394,
$\pm$ 0·94910 79123 42760.

As the functions $\mathrm{P}^n(x)$ contain only powers of 2 in the denominators the decimal values terminate, and in the following tables the complete values are given. Two independent calculations were made, one by Mr. Barrett Davis, and the other under the supervision of the reporter, by whom they were compared, corrected, and differenced. As the values in the tables are complete, the second, third,...seventh differences in the respective functions were absolutely constant, and thus afforded an exact verification. The calculations were performed seven years ago, and are referred to in the Report for 1873, p. 170; the tables were not published, however, as about that time the issue of a separate volume containing these and some other tables which it was proposed to calculate was contemplated by the Committee.

The plate (Plate I.) contains drawings of the curves $y = \mathrm{P}^1(x)$, $y = \mathrm{P}^2(x)$,...$y = \mathrm{P}^7(x)$ from $x = 0$ to $x = 1$, made from the tables. The positions of the roots of the functions are readily identified with the numerical values given above.

x	$P^1(x)$	$P^2(x)$	$P^3(x)$	$P^4(x)$
0	0	−0·5	0	+0·375
0·01	0·01	−0·49985	−0·0149975	+0·37462504375
0·02	0·02	−0·4994	−0·02998	+0·3735007
0·03	0·03	−0·49865	−0·0449325	+0·37162854375
0·04	0·04	−0·4976	−0·05984	+0·3690112
0·05	0·05	−0·49625	−0·0746875	+0·36565234375
0·06	0·06	−0·4946	−0·08946	+0·3615567
0·07	0·07	−0·49265	−0·1041425	+0·35673004375
0·08	0·08	−0·4904	−0·11872	+0·3511792
0·09	0·09	−0·48785	−0·1331775	+0·34491204375
0·10	0.10	−0·485	−0·1475	+0·3379375
0·11	0·11	−0·48185	−0·1616725	+0·33026554375
0·12	0·12	−0·4784	−0·17568	+0·3219072
0·13	0·13	−0·47465	−0·1895075	+0·31287454375
0·14	0·14	−0·4706	−0·20314	+0·3031807
0·15	0·15	−0·46625	−0·2165625	+0·29283984375
0·16	0·16	−0·4616	−0·22976	+0·2818672
0·17	0·17	−0·45665	−0·2427175	+0·27027904375
0·18	0·18	−0·4514	−0·25542	+0·2580927
0·19	0·19	−0·44585	−0·2678525	+0·24532654375
0·20	0·20	−0·44	−0·28	+0·232
0·21	0·21	−0·43385	−0·2918475	+0·21813354375
0·22	0·22	−0·4274	−0·30338	+0·2037487
0·23	0·23	−0·42065	−0·3145825	+0·18886804375
0·24	0·24	−0·4136	−0·32544	+0·1735152
0·25	0·25	−0·40625	−0·3359375	+0·15771484375
0·26	0·26	−0·3986	−0·34606	+0·1414927
0·27	0·27	−0·39065	−0·3557925	+0·12487554375
0·28	0·28	−0·3824	−0·36512	+0·1078912
0·29	0·29	−0·37385	−0·3740275	+0·09056854375
0·30	0·30	−0·365	−0·3825	+0·0729375
0·31	0·31	−0·35585	−0·3905225	+0·05502904375
0·32	0·32	−0·3464	−0·39808	+0·0368752
0·33	0·33	−0·33665	−0·4051575	+0·01850904375
0·34	0·34	−0·3266	−0·41174	−0·0000353
0·35	0·35	−0·31625	−0·4178125	−0·01872265625
0·36	0·36	−0·3056	−0·42336	−0·0375168
0·37	0·37	−0·29465	−0·4283675	−0·05638045625
0·38	0·38	−0·2834	−0·43282	−0·0752753
0·39	0·39	−0·27185	−0·4367025	−0·09416195625
0·40	0·40	−0·26	−0·44	−0·113
0·41	0·41	−0·24785	−0·4426975	−0·13174795625
0·42	0·42	−0·2354	−0·44478	−0·1503633
0·43	0·43	−0·22265	−0·4462325	−0·16880245625
0·44	0·44	−0·2096	−0·44704	−0·1870208
0·45	0·45	−0·19625	−0·4471875	−0·20497265625
0 46	0·46	−0·1826	−0·44666	−0·2226113
0·47	0·47	−0·16865	−0·4454425	−0·23988895625
0·48	0·48	−0·1544	−0·44352	−0·2567568
0·49	0·49	−0·13985	−0·4408775	−0·27316495625

x	$P^1(x)$	$P^2(x)$	$P^3(x)$	$P^4(x)$
0·50	0·50	−0·125	−0·4375	−0·2890625
0·51	0·51	−0·10985	−0·4333725	−0·30439745625
0·52	0·52	−0·0944	−0·42848	−0·3191168
0·53	0·53	−0·07865	−0·4228075	−0·33316645625
0·54	0·54	−0·0626	−0·41634	−0·3464913
0·55	0·55	−0·04625	−0·4090625	−0·35903515625
0·56	0·56	−0·0296	−0·40096	−0·3707408
0·57	0·57	−0·01265	−0·3920175	−0·38154995625
0·58	0·58	+0·0046	−0·38222	−0·3914033
0·59	0·59	+0·02215	−0·3715525	−0·40024045625
0·60	0·60	+0·04	−0·36	−0·408
0·61	0·61	+0·05815	−0·3475475	−0·41461945625
0·62	0·62	+0·0766	−0·33418	−0·4200353
0·63	0·63	+0·09535	−0·3198825	−0·42418295625
0·64	0·64	+0·1144	−0·30464	−0·4269968
0·65	0·65	+0·13375	−0·2884375	−0·42841015625
0·66	0·66	+0·1534	−0·27126	−0·4283553
0·67	0·67	+0·17335	−0·2530925	−0·42676345625
0·68	0·68	+0·1936	−0·23392	−0·4235648
0·69	0·69	+0·21415	−0·2137275	−0·41868845625
0·70	0·70	+0·235	−0·1925	−0·4120625
0·71	0·71	+0·25615	−0·1702225	−0·40361395625
0·72	0·72	+0·2776	−0·14688	−0·3932688
0·73	0·73	+0·29935	−0·1224575	−0·38095195625
0·74	0·74	+0·3214	−0·09694	−0·3665873
0·75	0·75	+0·34375	−0·0703125	−0·35009765625
0·76	0·76	+0·3664	−0·04256	−0·3314048
0·77	0·77	+0·38935	−0·0136675	−0·31042945625
0·78	0·78	+0·4126	+0·01638	−0·2870913
0·79	0·79	+0·43615	+0·0475975	−0·26130895625
0·80	0·80	+0·46	+0·08	−0·233
0·81	0·81	+0·48415	+0·1136025	−0·20208095625
0·82	0·82	+0·5086	+0·14842	−0·1684673
0·83	0·83	+0·53335	+0·1844675	−0·13207345625
0·84	0·84	+0·5584	+0·22176	−0·0928128
0·85	0·85	+0·58375	+0·2603125	−0·05059765625
0·86	0·86	+0·6094	+0·30014	−0·0053393
0·87	0·87	+0·63535	+0·3412575	+0·04305204375
0·88	0·88	+0·6616	+0·38368	+0·0946672
0·89	0·89	+0·68815	+0·4274225	+0·14959804375
0·90	0·90	+0·715	+0·4725	+0·2079375
0·91	0·91	+0·74215	+0·5189275	+0·26977954375
0·92	0·92	+0·7696	+0·56672	+0·3352192
0·93	0·93	+0·79735	+0·6158925	+0·40435254375
0·94	0·94	+0·8254	+0·66646	+0·4772767
0·95	0·95	+0·85375	+0·7184375	+0·55408984375
0·96	0·96	+0·8824	+0·77184	+0·6348912
0·97	0·97	+0·91135	+0·8266825	+0·71978104375
0·98	0·98	+0·9406	+0·88298	+0·8088607
0·99	0·99	+0·97015	+0·9407475	+0·90223254375
1	1	+1	+1	+1

x	$P^5(x)$	$P^6(x)$	$P^7(x)$
0	0	−0·3125	0
0·01	+0·0187412507875	−0·3118439468605625	−0·021855316830981875
0·02	+0·0374300252	−0·309878149076	−0·04359263856568
0·03	+0·0560139413625	−0·3066096863500625	−0·065094489407360625
0·04	+0·0744408064	−0·302050340864	−0·08624443080704
0·05	+0·0926587109375	−0·2962165712890625	−0·106927576708984375
0·06	+0·1106161236	−0·289129476404	−0·12703110474216
0·07	+0·1282619855125	−0·2808147483175625	−0·146444762006283125
0·08	+0·1455458048	−0·271302615296	−0·16506136410112
0·09	+0·1624177510875	−0·2606277741955625	−0·182777286047686875
0·10	+0·17882875	−0·2488293125	−0·19949294375
0·11	+0·1947305776625	−0·2359506199630625	−0·215113264646025625
0·12	+0·2100759552	−0·222039289856	−0·22954814619648
0·13	+0·2248186432375	−0·2071470098200625	−0·242712900860129375
0·14	+0·2389135364	−0·191329442324	−0·25452868620424
0·15	+0·2523167578125	−0·1746460947265625	−0·264922918798828125
0·16	+0·2649857536	−0·157160178944	−0·27382967054336
0·17	+0·2768793873875	−0·1389384607225625	−0·281190046074551875
0·18	+0·2879580348	−0·120051098516	−0·28695253990392
0·19	+0·2981836779625	−0·1005714719680625	−0·291073371933730625
0·20	+0·30752	−0·080576	−0·2935168
0·21	+0·3159324795375	−0·0601439485030625	−0·294255408091194375
0·22	+0·3233884852	−0·039357227636	−0·29327036889128
0·23	+0·3298573701125	−0·0183001787275625	−0·290551679295773125
0·24	+0·3353105664	+0·002940640216	−0·28609836754944
0·25	+0·3397216796875	+0·0242767333984375	−0·279918670654296875
0·26	+0·3430665836	+0·045617821516	−0·27203018069656
0·27	+0·3453235142625	+0·0668721864349375	−0·262459958741195625
0·28	+0·3464731648	+0·087946891264	−0·25124461494272
0·29	+0·3464987798375	+0·1087480648219375	−0·238430353520899375
0·30	+0·34538625	+0·1291811875	−0·22407298125
0·31	+0·3431242064125	+0·1491513875194375	−0·208237878110238125
0·32	+0·3397041152	+0·168563747584	−0·19099992875008
0·33	+0·3351203719875	+0·1873236219274375	−0·172443413408041875
0·34	+0·3293703964	+0·205336963756	−0·15266185694264
0·35	+0·3224547265625	+0·2225106630859375	−0·131757834619140625
0·36	+0·3143771136	+0·238752894976	−0·10984273330176
0·37	+0·3051446161375	+0·2539734781549375	−0·087036466699964375
0·38	+0·2947676948	+0·268084244044	−0·06346714331752
0·39	+0·2832603067125	+0·2809994161744375	−0·039270685752943125
0·40	+0·27064	+0·292636	−0·0145904
0·41	+0·2569280082875	+0·3029141831044375	+0·010423506603093125
0·42	+0·2421493452	+0·311757745804	+0·03561446012712
0.43	+0·2263328988625	+0·3190944821449375	+0·060820108859314375
0·44	+0·2095115264	+0·324856631296	+0·08587296751616
0·45	+0·1917221484375	+0·3289813193359375	+0·110601118212890625
0·46	+0·1730058436	+0·331411011436	+0·13482896954104
0·47	+0·1534079430125	+0·3320939744374375	+0·158378075105391875
0·48	+0·1329781248	+0·330984749824	+0·18106801287168
0·49	+0·1117705085875	+0·3280446370894375	+0·202717326676388125

x	$P^5(x)$	$P^6(x)$	$P^7(x)$
0·50	+0·08984375	+0·3232421875	+0·22314453125
0·51	+0·0672611351625	+0·3165537082519375	+0·242169182105049375
0·52	+0·0440906752	+0·307963777024	+0·25961301164032
0·53	+0·0204052007375	+0·2974657669249375	+0·275301132812545625
0·54	−0·0037175436	+0·285062381836	+0·28906331172696
0·55	−0·0281948046875	+0·2707662021484375	+0·300735310498046875
0·56	−0·0529387264	+0·254600240896	+0·31016030173184
0·57	−0·0778562551125	+0·2365985102824375	+0·317190355981123125
0·58	−0·1028490452	+0·216806598604	+0·32168800352488
0·59	−0·1278133645375	+0·1952822575669375	+0·323527871823344375
0·60	−0·15264	+0·172096	+0·3225984
0·61	−0·1772141629625	+0·1473317079619375	+0·318803631701880625
0·62	−0·2014153948	+0·121087251244	+0·31206508768952
0·63	−0·2251174723875	+0·0934751162674375	+0·302323719507901875
0·64	−0·2481883136	+0·064623045376	+0·28954194558976
0·65	−0·2704898828125	+0·0346746865234375	+0·273705771142578125
0·66	−0·2918780964	+0·003790253356	+0·25482699317064
0·67	−0·3122027282375	−0·0278528043100625	+0·232945491983479375
0·68	−0·3313073152	−0·060059119616	+0·20813161054208
0·69	−0·3490290626625	−0·0926147173930625	+0·180488622994175625
0·70	−0·36519875	−0·1252863125	+0·15015529375
0·71	−0·3796406360875	−0·1578205977655625	+0·117308528449836875
0·72	−0·3921723648	−0·189943521536	+0·08216611817472
0·73	−0·4026048705125	−0·2213595548275625	+0·044989578251633125
0·74	−0·4107422836	−0·251750948084	+0·00608708300456
0·75	−0·4163818359375	−0·2807769775390625	−0·034183502197265625
0·76	−0·4193137664	−0·308073181184	−0·07541149024256
0·77	−0·4193212263625	−0·3332505843400625	−0·117130141581289375
0·78	−0·4161801852	−0·355894914836	−0·15881333217672
0·79	−0·4096593357875	−0·3755658077905625	−0·199872118754868125
0·80	−0·39952	−0·391796	−0·2396512
0·81	−0·3855160342125	−0·4040905139305625	−0·277425272344831875
0·82	−0·3673937348	−0·411925831316	−0·31239527900408
0·83	−0·3448917436375	−0·4147490563600625	−0·343684550900010625
0·84	−0·3177409536	−0·411977068544	−0·37033483812864
0·85	−0·2856644140625	−0·4029956650390625	−0·391302230615234375
0·86	−0·2483772364	−0·387158692724	−0·40545296660776
0·87	−0·2055864994875	−0·3637871698075625	−0·411559127656933125
0·88	−0·1569911552	−0·332168397056	−0·40829421873152
0·89	−0·1022819339125	−0·2915550586255625	−0·394228632117536875
0·90	−0·04114125	−0·2411643125	−0·36782499375
0·91	+0·0267568926625	−0·1801768705330625	−0·327433390625875625
0·92	+0·1017469952	−0·107736068096	−0·27128647794688
0·93	+0·1841721582375	−0·0229469233300625	−0·197494464640779375
0·94	+0·2743841764	+0·075124813996	−0·10403997590984
0·95	+0·3727436328125	+0·1874536240234375	+0·011227208544921875
0·96	+0·4796199936	+0·315055188736	+0·15059554197504
0·97	+0·5953917023875	+0·4589873742874375	+0·316497225062798125
0·98	+0·7204462748	+0·620351223724	+0·51151384877768
0·99	+0·8551803929625	+0·8002919601019375	+0·738382166962419375
1·00	+1	+1	+1

Sixth Report of a Committee, consisting of Professor A. S. Herschel, *M.A., F.R.A.S.*, Professor G. A. Lebour, *F.G.S., and* Mr. J. T. Dunn, *B.Sc., on Experiments to determine the Thermal Conductivities of certain Rocks, showing especially the Geological Aspects of the Investigation.*

The research and correspondence necessary for the completion of an historical sketch of the attempts hitherto made to determine experimentally the Thermal Conductivities of various Rocks occurring widely over the earth's surface, which the Committee proposed to prepare during the past year, are not so far advanced at present as to allow them to be comprehended in this year's Report. The Committee hopes, by continuing its enquiries for another year, with the addition to its numbers of Professors W. E. Ayrton and J. Perry, of the Imperial College of Engineering in Japan, who have pursued the subject practically with the greatest attention and success, to carry out the object of their undertaking, so as to exhibit the present state of our knowledge of the data of Thermal Conductivity, needful for discussions of the conditions of the earth's temperature, which have been determined by observations and experiments.

In a paper of great practical interest in this respect,[1] published at the end of the year 1876, by Professor Stefan, of Vienna, a series of experiments is described, by which he determined very accurately the absolute thermal conductivity of ordinary Ebonite. The process used being the same in principle (although differing from it a little in its details), as that adopted by Professors Ayrton and Perry for determining the thermal conductivity of some specimens of a kind of Japanese building-stone, employs for its application Fourier's formulæ, and therefore gives the absolute conductivity, in the first instance, indirectly, or only in terms of the heat-capacity of a cubic centimetre of the trial-substance as the unit of heat-quantity, instead of in absolute heat-units. The value in absolute heat-units of this thermal capacity of the substance has then to be determined by a subsidiary experiment. As the very trustworthy value found by this otherwise convenient method affords a useful standard for comparison with other methods, that adopted by the Committee was checked, during the past year, by applying it to determine directly the thermal conductivity of a plate of ordinary ebonite, together with that of some plates of vulcanised indiarubber, with which, by the courtesy of their agent in Newcastle, Mr. W. Beer, the Committee was furnished from the Silvertown Works of the Indiarubber and Guttapercha Company in London.

Some omitted measurements of rock conductivities were also made at the close of the past year, with the Committee's apparatus. But owing to some deterioration which it has in the meantime undergone in its condition, they are insufficiently high, as proved by the values found for red serpentine and white Sicilian marble. As the results, however, possess a relative value among themselves, and also in relation to these two specimens of which the conductivities have before been very well determined, they are added to the last-mentioned observations, in the accompanying

[1] 'Sitzungsberichte' of the Imperial Academy of Sciences of Vienna, vol. for 1876, part ii.; November, 1876.

Table, with the probable values which they may be conjectured to indicate very nearly as concluded from comparisons of the known with the defectively observed conductivities of the two rock-plates of reference.

The uncertainty which attached, in last year's Report, to the observations of the specific heats of some porous rocks, has now been removed by repeating the experiment of boiling them in water, and immediately weighing them to determine the quantity of boiling-hot water which they absorbed. The result is that the assumption made in last year's Report that the quantity of water so imbibed is in general half the weight which they are found to have gained by an immediate immersion, after boiling, in cold water, is fully verified. The fraction of the total water-gain which, for example, entered the six specimens of Craigleith sandstone during the first process of boiling them, had the real values 0·41–0·49 (average 0·45). The corrections which the specific heats of these porous sandstones given in the Table of last year's Report require for this little imperfection of the adopted allowance is so small as only to affect by a single significant unit (and in the ratio $\frac{k}{c}$ by one or two units), a few of the thirty numbers given for these sandstones in the Table. The same substantiation of the figures in the Table has been found for all the sandstones (water-absorption 6·1–8·4 per cent.), and other rocks (including Mansfeld limestone, absorption 8·1 per cent.), not exceeding them in porosity. Newcastle firebrick (absorption 14·3 per cent.) is an extreme case in which the allowance adopted, and the values of the specific heats, and of the ratio, $\frac{k}{c}$, given in the Table require no sensible correction. In rocks which, like the last, exceed the pure sandstones in porosity, the rule for correcting the Table illustrated by examples in the last Report, to regard the allowance adopted in the Table as too little by a half, is now proved to be substantially correct, the ratios for Caenstone, Great Pyramid, and Castle Eden limestones, Godstone chalk,[1] firestone, and sandstone, magnesite, and plaster-of-Paris, all lying between 0·74 and 0·85, the last of which ratios is an exceptionally high proportion, for Castle Eden limestone.

On correcting the tabular specific heats of these very porous rocks (as has been done in the short recapitulation of them given below, in the manner described by some examples in last year's Report), by the actual fractions of total water-gain now found to have been introduced into the plates by boiling them, a close agreement of the corrected values (with only one exception) is produced with the common value, about 0·20, of the heat-capacities of nearly all the other rocks recorded in the Table. The real specific heat, by weight of plaster-of-Paris alone, agrees (as was surmised correctly in last year's Report) with that of English alabaster, or gypsum, and nearly also with red and green serpentine from Cornwall, in being exceptionally high (0·26–0·28). If the metallic ores, galena and iron pyrites, are excluded from the list, the only other examples of rocks in the Table, whose specific heats differ by more than one or two significant units from the common value, 0·20, are the specimens of Newcastle black shale (0·29), and coal of two varieties, cannel coal, and ordinary pit-coal,

[1] The specimen of pure white chalk, whose thermal properties, as partly tested, have been previously described in these Reports, having yielded and crumbled last year in the experiment on its specific heat, could not be submitted this year to a repetition of the same experiment.

which have the extreme specific heats by weight, 0·29 and 0·37. The present well-measured specific heat of pumice stone (0·24, unless the plate contained a considerable quantity of hygroscopic moisture), is also appreciably above the common value to which the heat-capacities of nearly all the different descriptions of rocks tested approximate very closely in the Table.

To the above-proved rule of partial water-absorption by boiling, among the very porous rocks, the plate of pumice stone presented an exception. While absorbing a fifth of a pound (75·6 per cent. of its weight) of water by boiling and immediate immersion in cold water, which far surpasses the observed porosity of any other porous kind of rock examined, only three-quarters of an ounce, or 0·21 of the former quantity, enters the plate, and occupies its pores during the process of boiling only.[1] The fraction of half the total water gain, provisionally assumed in the Table to be introduced into the porous rocks by boiling, is therefore here too great, instead of too little, by about a half of its amount. The large uncertainty, until this plate's water-absorption could be re-observed, led to the omission, in the Table of last year's Report, of the data found for pumice stone, the real values of which are now given in the subjoined list of verified determinations.

In the hope of discovering an explanation of the wide difference which exists between the various conductivities hitherto recorded in these Reports, and a list of similar conductivities published in the Proceedings of the Royal Society of Edinburgh in 1873 (vol. viii., p. 66), by Professor G. Forbes (the values in which are not more than a fourth or a fifth of those described in these Reports), the Committee requested Professor Forbes to search for possible errors among the numbers used as constant factors in his calculations, while it submitted its own reductions to a similar examination. The result of Professor Forbes's re-examination is not yet received; but the Committee has had the annoyance to find that one such small error has unsuspectedly been committed in its own determinations.

Among the factors used, since the outset of its experiments, to convert into terms of absolute conductivity the rate of heat-flow measured directly in the 5-inch plates, a number, 196, was used inadvertently in place of the correct multiplier, 220, to effect a portion of the transformation. All the observed values that have hitherto been described in these Reports as obtained from year to year of the absolute conductivities (k), and of the ratio $\frac{k}{c}$ of the various rock-specimens which have been tested are there-

[1] Equally irregular departures from perfect conformity to a common rule occur in some examples of the less porous kinds of rocks, where the very moderate absorption of water, however, renders the deviations of their properties of little sensible influence, as affecting the provisionally assigned values of their specific heats so as to make them needful of any appreciable corrections. The hot-water absorption by gas coke is like that of pumice stone, but a quarter, instead of a half or three-quarters of its total water gain, which in this slightly porous substance is only 2·9 per cent. by weight. The small correction which this entails on the specific heat by weight (0·193), as given in the Table, is the additional quantity 0·0073, making the real specific heat from the experiments, 0·2003. This is even more nearly identical with the value, 0·201, for coke of anthracite, given by Regnault, than the former provisional value was, the near agreement of which with Regnault's determination was pointed out in the comparative Table of such observations in last year's Report.

fore deficient in their recorded values by an eighth part of their assigned magnitudes. While requiring this addition of an eighth part to their magnitudes, the absolute resistances given as the practical results of the experiments, require, to correct them for the same source of error, to be diminished by a ninth part of their stated values. Examples of the needful corrections which will suffice to remove the misconstructions introduced by this entirely unsuspected error of reduction, are given in the last three columns of the accompanying short Table of amended data. The values of the measures k and $\frac{k}{c}$ in the three preceding adjoining columns are increased, for correctness, in these new columns by an eighth part; while in the same columns the absolute resistances given in the former columns are diminished by a ninth part of their values. The Committee desires to submit this easy process of correction as an immediately necessary treatment of all the experimental results of absolute thermal conductivities and resistances at which it has arrived, and which have hitherto been published in the pages and Tables of these Reports, before the present year, for their proper emendation. It will then be found by comparisons, to which the Committee hopes to revert particularly in another year, that a somewhat closer agreement than was exhibited in last year's Report does actually exist between its corrected determinations and those sure, indubitable data of rates of thermal conductivity in certain terrestrial rocks which able and elaborate reductions of several extensive series of observations of underground thermometers have made known. A valuable store of new materials, it may be noticed, for these last investigations was furnished by the publication last year, in the volume of 'Greenwich Meteorological Reductions, chiefly for the years 1847–73,' of the continuous records during this interval of twenty-seven years, of the deep-sunk underground thermometers in the grounds of the Royal Observatory at Greenwich; only the first half of which valuable results have yet been utilised (by Professor Everett) for deducing the constant of thermal conductivity of the great eminence of gravel strata upon which the Observatory is placed.

CORRECTED DATA OF THERMAL PROPERTIES OF CERTAIN VERY POROUS ROCKS, 1879.

Rock-specimen; or substance tested	Specific heat. Dry (wet)		Values obtained by					
			Earlier and erroneous reduction-factor (196), 1874–78			New and correct reduction-factor (220), 1879		
	By weight C (1879)	By volume c (1879)	Absolute dry (wet)		Ratio $\frac{k}{c}$ (1879)	Absolute dry (wet)		Ratio $\frac{k}{c}$
			Conductivity k	Resistance		Conductivity k	Resistance	
			(1)	(2)	(3)	(4)	(5)	(6)
Sandstone (Godstone; greensand)	0·22 (0·36)	0·33 (0·66)	—	—	—	—	—	—
Firestone (Godstone; greensand)	0·22 (0·36)	0·35 (0·66)	·0021	474	·0059	·0024	421	·0066
Building Limestone (Caen, Normandy)	0·21 (0·30)	0·43 (0·66)	·0043	231	·0102	·0049	205	·0115
Building Limestone (Gt. Pyr., Casing-stone)	0·20 (0·30)	0·43 (0·67)	·0040	250	·0092	·0045	222	·0104
Magnesite,[1] white amorphous (Pignerol, Genoa)	·24 (·35)	·45 (·75)	—	—	—	·0044	227	·0098
Magnesian Limestone (porous; much magnesia; Castle Eden, Durham)	0·19 (0·31)	0·34 (0·68)	·0053	188	·0155	·0060	167	·0174
Chalk (Godstone, Surrey)	0·21 (0·35)	0·36 (0·70)	·0020	500	·0056	·0022	445	·0063
Pumice stone.	0·24 (0·57)	0·14 (0·61)	·0005 (·0010)	1818 (971)	·0038 (·0017)	·0006 (·0012)	1616 (863)	·0043 ·0019
Fine Plaster-of-Paris (a light plate)	0·26 (0·51)	0·27 (0·79)	·0012 (·0016)	833 (625)	·0045 (·0020)	·0013 (·0018)	740 (555)	·0051 (·0023)

[1] New observations of the specific heats of Magnesite, and of Frosterley and Dent marbles, have shown that the numbers found for them last year are fallacious. The specific heats by weight and volume of the last two rocks are really; Frosterley, ·21, ·57; Dent, ·22, ·60, which agree very nearly with those which have been observed in the other limestone and marble specimens of the list. When corrected for the known weight of water which it absorbed in boiling, the specific heat by weight of Magnesite observed last year becomes 0·175; lower than that of limestone, instead of higher as should be expected from this rock's lighter molecular weight. The real value now found of its specific heat is the exceptionally high one 0·245; a specimen of hard crystalline magnesite from Trieste also giving 0·244. Compared with Regnault's specific heats of some earthy carbonates, and with their molecular weights, this high specific heat of magnesite appears to be quite in accordance with the low place which it occupies among those carbonates in its combining weight, thus:—

Substance	Specific Heat (Regnault) C	Specific Heat in these Reports C	Molecular Weight, m.	Molecular Specific Heat, $m \times C$
Baric Carbonate	·11038	—	197	21·74
Strontic Carbonate	·14483	—	147·6	21·38
Calcic Carbonate	·21150	Avrge 0·210	100	21·15
Magnesic Carbonate	—	„ 0·2445	84	20·54

ABSOLUTE THERMAL CONDUCTIVITIES OBTAINED IN A DEFECTIVE AND UNDERRATING CONDITION OF THE APPARATUS, 1879.

		(1)		(4)	(5)	(6)
White Chalk (Alum Bay, I. of Wight)	Water absorbed in exper. 10 p. c. by wt.	·0012	Obs. 1879	·0014		
			prob. value	·0028	357	
Magnesite (White, Amorphous; Pignerol, Genoa)	„	·0019	Obs. 1879.	·0022		
			prob. value	·0044	327	·0107
Red Serpentine (Cornwall)		·0020	Obs. 1879	·0023		
		·0040	Obs. 1875	·0045		
White Sicilian Marble		·0027	Obs. 1879	·0031		
		·0054	Obs. 74–78	·0060		
Sandstone (Valley of Rocks, Linton)		·0027	Obs. 1879	·0030		
			prob. value	·0060	167	·0115
Ganister		·0028	Obs. 1879	·0032		
			prob. value	·0063	159	·0127

MEASURES (IN 1879), COMPARED WITH STEFAN'S DETERMINATION (1876), TO TEST THE ACTION OF THE APPARATUS.

Black Ebonite; two experiments	Mean. tem. of plate, 120° F.	·00032	(Obs. 1879)	·00036	2778	
		·00034	„ „	·00038	2632	
			(Stefan, 1876)	·00026	Temp.	35° F.
Soft, red vulcanised caoutchouc	120° F.	·00030	(Obs. 1879)	·00034	2941	
Soft, grey vulcanised (nearly pure caoutchouc)	115° F.	·00039	„ „	·00044	2273	
Hard, grey vulcanised (containing much litharge)	110° F.	·00049	„ „	·00055	1802	

Report of a Committee, consisting of Professor G. FORBES, Professor Sir WILLIAM THOMSON, and Professor EVERETT, *appointed to obtain Observations on Atmospheric Electricity at Madeira. Drawn up by* Dr. GRABHAM, *Madeira.*

ONE of the latest of Sir William Thomson's portable electrometers was entrusted to me two years ago for taking electrical observations in Madeira. I received no intimation as to any particular set of observations which were thought desirable to take, and I have hence considered myself unfettered to seek out that which seemed most inviting and most likely to yield new facts.

The *daily observations* I discarded, finding them extremely monotonous and irksome, and I think they are not likely to prove instructive at all, unless a continuous record is made by automatic means. But it is obvious that in so uniform a climate as that of Madeira, where calm fine weather often lasts steadily for several weeks without a break, a station for observing the diurnal and seasonal electric variations would be extremely valuable.

I have, however, devoted whatever time I have been able to give to this subject to the observation of the regular breezes and prevailing winds. Early in the morning, in ordinary fine weather, there is no wind

at all, and there is then shown positive electricity of very moderate intensity.

The electricity, however, rises very rapidly, and comes to a maximum at about half-past eleven o'clock, and seems to correspond very much with the flow of the sea breeze—which the sun shining on the land causes with great regularity—and also with the accumulation of masses of cloud or watery vapour, which rise and coalesce to form a thin screen during the hottest part of the day over the basin of Funchal.

It is curious that the index of the electrometer, which is extremely unsteady and oscillating whilst the electricity is rising—probably from the influence of masses of variously electrified vapour or air in motion—becomes steady, and remains fairly steady for two hours or more—during which time the maximum is maintained. The electricity then subsides, as the cloud-screen breaks up early in the afternoon, at first suddenly, and then very gradually until evening, when it faintly begins to rise again.

The formation of the thin above cloud-layer over Funchal is very regular, and occupies a vertical space of about 200 feet, at an altitude of 2,500 feet, varying slightly with temperature and atmospheric pressure, and appearing, from a distance at sea, as a thin white sheet, beyond which the black rocky peaks of the island shoot up for several thousand feet.

The electricity below this cloud is always positive and moderately intense; in the cloud itself it is still positive, though feeble; and above the cloud, in a sheltered situation where these observations were taken, it is still positive, though still more feeble, and very irregular.

In warmer weather, as regards this cloud, the same conditions exist exactly, although the moisture forming the cloud does not condense, but appears from above as a dense blue transparent haze, liable, however, to become opaque on any accidental puff of colder air.

In my own garden I found that every observation was mitigated or quite vitiated by the numbers of lofty trees closely planted together.

The currents of air constituting the daily sea-breeze of Madeira are of no great depth, perhaps 70 or 80 feet, and above the true wind blows in the contrary direction.

I have often succeeded in flying a kite through the sea-breeze into the upper wind, and have made some attempts, abortive for want of proper insulation, to bring down the electricity of the upper current.

The electricity, however, of this upper current, which in fine settled weather is the north-east trade wind, can easily be observed on exposed mountain ridges, and always gives a steadily moderate indication of a positive quality. Indeed, the only observations of the north-east trade ever thought to have given a negative result were taken on a lesser peak of Teneriffe with inferior instruments by Mr. Smyth, who, however, attaches little value to them.

For my own part I have not had a single observation of negative electricity in the atmosphere at any time, if I may exclude faint oscillations of the needle, when there has been no ponderable quantity either way.

In Madeira, at the termination of a long period of fine weather, on the approach of rain clouds I have noticed a high electricity of a positive character, very transient and irregular in character, and falling very low when it actually rained. Rising electricity on the cessation of rain is here, as in all other places, an important factor in forecasting weather.

But Madeira is occasionally subject, especially in summer weather, to another wind of very peculiar character. This is a kind of Sirocco, called

in Portuguese 'l'Este,' which blows with great force, striking in its integrity in a curious manner certain districts alone.

The wind appears to be generated in the sandy tract of the Great Sahara, and also perhaps beyond in districts extending far into Asia. The heated air of those burning plains ascends tumultuously and pursues a course more or less easterly across the Atlantic. Far above the surface of the water it can imbibe no moisture, and after its descent has become possible by a partial loss of heat it strikes upon the surface of Madeira, depositing sand, locusts, birds, and other evidence of its distant origin, and for a while the mid-day climate of the Great Desert is felt 400 miles away from Africa, in the middle of the Atlantic. The dryness of this wind is wonderful; it will, in its greedy power of evaporation, separate the dry and wet bulbs of Mason's hygrometer 25° or more, and in a temperature of 80 F. the dew-point is below the freezing point. All clouds disappear, and the sun shines hazily in a sky which exchanges its ordinary deep blue for a semi-transparent colour of light grey.

The electrical quality of this wind is simply a blank. I have been unable during four favourable opportunities for observing it to detect any registerable amount, either positive or negative; but I can see under a high magnifying power an irregular swaying to and fro of the needle similar in character to those given by a broken submerged cable. Probably at its origin, and especially if it takes up much sand, the wind is resinously charged; but it will be interesting to determine whether an intensely dry wind can be strongly electrified or electrified at all.

In the neighbourhood of strong l'Este winds I have also made a few observations on some curiously rounded clouds which hang with singular immobility over deep mountain gorges, although tossed and tumbled by strong wind on their upper surfaces.

I have some evidence to show that both their power and quietness relate to their somewhat high electrical charge, and it is probable that we shall find by-and-by in a more general way that the form of clouds depends very much on the influence of neighbouring electrified masses, in a manner nearly related to the experiments of Lord Rayleigh on fountain-jets. But these cloud observations are both difficult and somewhat dangerous. If any one should be tempted to fly a kite with a wet cord and a metallic conductor in its tail down into one of these mountain clouds, he should place his electrometer upon the ground or else have a long trailing copper chain attached to the brasswork. The umbrella, too, must be kept low. If these precautions are neglected a very painful shock will probably be felt, which may cause the observer to drop the instrument.

The very meagreness of this Report is enough to show the necessity for multiplying electrometric observations. I would only ask, Has the electrometer yet any share in determining our weather forecasts, or is electricity thought of in the relations of meteorology to the public health? I fear not.

The fascinating little instrument is my constant companion and the solace of many a leisure moment. It has been taken to the north and south of this country, and has twice crossed the Atlantic with me. Indeed, it never failed to answer every question certainly and sensitively until I attempted last Sunday to take it to St. Paul's in London to take an observation under the dome. Then the pumice-stone broke, and poured its corrosive fluid upon the brasswork.

I can only regret that so little help is to be got from the text-books on electricity in these observations. They appear to devote most of their space given to atmospheric electricity to a picture of Franklin holding a kite under a shed, and another picture of a waterspout.

Report of the Committee, consisting of Professor SYLVESTER, *F.R.S.*, *and* Professor CAYLEY, *F.R.S.*, *appointed for the purpose of calculating Tables of the Fundamental Invariants of Algebraic Forms.*

WITH a portion of the grant made last year, the valuable services of Mr. F. Franklin, of the Johns Hopkins University, have been obtained to aid in computing, under Professor Sylvester's inspection, the *ground forms* (otherwise called the fundamental invariants and covariants) of binary quantics of the 7th, 8th, and 10th orders respectively, thus rendering the list of tables of such forms complete for quantics of all orders up to the 10th inclusive.

The sheets containing the calculations referred to are deposited provisionally in the Library of the Johns Hopkins University at Baltimore, where they remain subject to the direction of the Council of the British Association as to their future disposal.

The tables of the *ground forms* of the seventhic are published in the *Comptes Rendus* of the Academy of Sciences at Paris, 1878; the table of the *ground forms* of the ninethic in the 'American Journal of Mathematics,' March, 1879, and in a future number of that Journal will shortly also appear the intermediary tables of the Generating Functions from which such *ground forms* are deduced, as also the *ground forms* and generating functions connected with the tenthic.

These tables, in addition to those previously constructed, will, it is believed, form a valuable, and (for the present) a sufficient basis for the prosecution of this kind of research in what regards the theory of single binary quantics, leaving a wide field still open for computations of a similar nature connected with systems of binary quantics and ternary and quaternary quantics, single or in systems.

Report of the Committee, consisting of the Rev. SAMUEL HAUGHTON, *M.D.*, *and* BENJAMIN WILLIAMSON, *M.A.*, *appointed for the Calculation of Sun-Heat Coefficients. Drawn up by* Dr. HAUGHTON.

THE calculation of the quantity of sun-heat received at a given place, and in a given time, on the earth's surface, neglecting the heat absorbed by the atmosphere, was solved by Lambert in the middle of the last century, and the researches of Poisson, Meech, and others have added very little to the work done by Lambert.

I have myself published a simple solution of Lambert's problem, depending on trigonometrical series, well known and readily applied,[1] copies of which are now offered to Section A.

[1] *Proceedings*, Royal Dublin Society, 1878.

When the absorption of heat by the atmosphere is neglected we have merely to *integrate*

$$A\int \cos z\, dh \qquad (1)$$

from sunrise to sunset, where

A = the solar constant of radiation,
z = sun's zenith distance,
h = sun's hour angle;

an integration readily performed; and then *sum* the results from day to day, from the summer to the winter solstice; a summation which presents no serious difficulty.

But when we attempt to compute the sun-heat received in a given time and at a given latitude, allowing for the absorption of sun-heat by the atmosphere, we are met by formidable mathematical difficulties which have never yet been seriously acknowledged and attacked.

It is, in fact, easy to see that we must now attempt the integration, daily, from sunrise to sunset, of

$$A\int p^u \cos z\, dh, \qquad (2)$$

instead of

$$A\int \cos z\, dh,$$

where

p = the atmospheric constant of absorption;
$u = \sqrt{2rh + h^2 + r^2 \cos^2 z} - r \cos z$;
h = height of homogeneous atmosphere;
r = radius of earth.

It is evident at sight that equation (2) is not integrable; and if we attempt to integrate it by series we fail completely, for the following reason:—

It will be seen, on trial, that the expansion of

$$p^u \cos z$$

must be of the form

$$\begin{aligned} &A_0 + A_1 \cos z + A_2 \cos^2 z + \&c.; \\ &\quad + B_1 \sec z + B_2 \sec^2 z + \&c. \end{aligned} \qquad (3)$$

This series is to be multiplied by dh, and each term integrated from sunrise to sunset. This is easily done for the cosine terms, but the secant terms become infinite at the limits, because $z = 90°$ at sunrise and sunset. Hence any attempt to obtain the value of integral (2) by approximation must be illusory, no matter how rapidly the coefficients

$$B_1, B_2, B_3, \&c.,$$

may diminish.

Under these circumstances it was proposed at the Dublin meeting of the British Association (1878), to apply a small grant (30*l.*) to a preliminary quadrature of equation (2), at a few well-defined latitudes, such as 0°, 30°, and 60°.

The method used was the following:—

1°. The values of $p^u \cos z$, for every value of z from 0° to 90°, were first calculated, from which the values of $p^u \cos z$, for every zone of zenith distance, one degree in width, were readily found.

These results are exhibited in the following table :—

z	u	p^u	$p^u \cos z$	$p^u \cos z$	z
90°	12·6480	0·0312	0·0000		
				0·0004	89° 30′
89°	11·3296	0·0448	0·0007		
				0·0014	88° 30′
88°	10·1600	0·0617	0·0021		
				0·0032	87° 30′
87°	9·1368	0·0817	0·0042		
				0·0057	86° 30′
86°	8·2448	0·1044	0·0072		
				0·0092	85° 30′
85°	7·4712	0·1290	0·0112		
				0·0137	84° 30′
84°	6·8008	0·1551	0·0161		
				0·0191	83° 30′
83°	6·2208	0·1818	0 0221		
				0·0256	82° 30′
82°	5·7168	0·2087	0·0290		
				0·0329	81° 30′
81°	5·2784	0·2354	0·0368		
				0·0411	80° 30′
80°	4·8952	0·2615	0·0454		
				0·0500	79° 30′
79°	4·5592	0·2867	0·0547		
				0·0596	78° 30′
78°	4·2632	0·3109	0·0646		
				0·0699	77° 30′
77°	4·0000	0·3341	0·0751		
				0·0806	76° 30′
76°	3·7664	0·3562	0·0861		
				0·0919	75° 30′
75°	3·5576	0·3772	0·0976		
				0·1035	74° 30′
74°	3·3704	0·3970	0·1094		
				0·1155	73° 30′
73°	3·2008	0·4160	0·1216		
				0·1278	72° 30′
72°	3·0480	0·4337	0·1340		
				0·1403	71° 30′
71°	2·9088	0·4506	0·1467		
				0·1531	70° 30′
70°	2·7816	0·4666	0·1596		
				0·1660	69° 30′
69°	2·6664	0·4816	0·1725		
				0·1791	68° 30′
68°	2·5600	0·4958	0·1857		
				0·1923	67° 30′
67°	2·4616	0·5094	0·1990		
				0·2056	66° 30′
66°	2·3720	0·5220	0·2123		
				0·2190	65° 30′
65°	2·2880	0·5342	0·2257		
				0·2324	64° 30′
64°	2·2112	0·5455	0·2391		
				0·2458	63° 30′
63°	2·1392	0·5564	0·2526		
				0·2593	62° 30′
62°	2·0728	0·5666	0·2660		
				0·2727	61° 30′
61°	2·0104	0·5764	0·2794		
				0·2861	60° 30′
60°	1·9536	0·5855	0·2927		
				0·2994	59° 30′
59°	1·8976	0·5945	0·3062		
				0·3128	58° 30′
58°	1·8464	0·6029	0·3195		
				0·3261	57° 30′
57°	1·7984	0·6109	0·3327		
				0·3392	56° 30′
56°	1·7536	0·6184	0·3458		
				0·3523	55° 30′
55°	1·7112	0·6256	0·3588		
				0·3653	54° 30′
54°	1·6712	0·6325	0·3718		
				0·3782	53° 30′
53°	1·6336	0·6391	0·3846		
				0·3910	52° 30′
52°	1·5976	0·6454	0·3973		
				0·4036	51° 30′
51°	1·5640	0·6514	0·4099		
				0·4161	50° 30′
50°	1·5328	0·6570	0·4223		
				0·4284	49° 30′
49°	1·5024	0·6625	0·4346		
				0·4407	48° 30′
48°	1·4736	0·6678	0·4468		
				0·4528	47° 30′
47°	1·4464	0·6727	0·4588		
				0·4647	46° 30′
46°	1·4208	0·6775	0·4706		
				0·4764	45° 30′
45°	1·3968	0·6820	0·4822		
				0·4879	44° 30′
44°	1·3736	0·6863	0·4937		
				0·4993	43° 30′
43°	1·3512	0·6905	0·5050		
				0·5105	42° 30′
42°	1·3304	0·6945	0·5161		
				0·5215	41° 30′
41°	1·3104	0·6983	0·5270		
				0·5323	40° 30′
40°	1·2912	0·7020	0·5377		
				0·5429	39° 30′
39°	1·2736	0·7054	0·5481		
				0·5533	38° 30′
38°	1·2560	0·7088	0·5585		
				0·5635	37° 30′
37°	1·2400	0·7119	0·5686		
				0·5735	36° 30′
36°	1·2240	0·7150	0·5784		
				0·5832	35° 30′
35°	1·2096	0·7178	0·5880		
				0·5927	34° 30′
34°	1·1952	0·7207	0·5975		
				0·6020	33° 33′
33°	1·1816	0·7234	0·6066		
				0·6111	32° 30′

z	u	p^u	$p^u \cos z$	$p^u \cos z$	z
32°	1·1688	0·7259	0·6156		
31°	1·1568	0·7283	0·6243	0·6199	31° 30′
30°	1·1448	0·7307	0·6328	0·6285	30° 30′
29°	1·1336	0·7330	0·6410	0·6369	29° 30′
28°	1·1232	0·7350	0·6490	0·6450	28° 30′
27°	1·1136	0·7370	0·6566	0·6528	27° 30′
26°	1·1040	0·7389	0·6641	0·6604	26° 30′
25°	1·0944	0·7409	0·6714	0·6678	25° 30′
24°	1·0864	0·7425	0·6783	0·6748	24° 30′
23°	1·0784	0·7441	0·6849	0·6816	23° 30′
22°	1·0704	0·7458	0·6915	0·6882	22° 30′
21°	1·0632	0·7472	0·6976	0·6945	21° 30′
20°	1·0568	0·7485	0·7033	0·7004	20° 30′
19°	1·0496	0·7500	0·7091	0·7062	19° 30′
18°	1·0440	0·7512	0·7144	0·7118	18° 30′
17°	1·0384	0·7523	0·7195	0·7169	17° 30′
16°	1·0328	0·7535	0·7243	0·7219	16° 30′
15°	1·0280	0·7545	0·7287	0·7265	15° 30′
14°	1·0230	0·7555	0·7330	0·7309	14° 30′
13°	1·0192	0·7563	0·7369	0·7349	13° 30′
12°	1·0152	0·7571	0·7406	0·7387	12° 30′
11°	1·0120	0·7578	0·7439	0·7422	11° 30′
10°	1·0088	0·7584	0·7469	0·7454	10° 30′
9°	1·0056	0·7591	0·7498	0·7483	9° 30′
8°	1·0032	0·7596	0·7522	0·7510	8° 30′
7°	1·0008	0·7601	0·7544	0·7533	7° 30′
6°	0·9992	0·7605	0·7563	0·7553	6° 30′
5°	0·9968	0·7610	0·7581	0·7572	5° 30′
4°	0·9960	0·7611	0·7593	0·7587	4° 30′
3°	0·9952	0·7613	0·7602	0·7597	3° 30′
2°	0·9944	0·7615	0·7610	0·7606	2° 30′
1°	0·9936	0·7616	0·7615	0·7612	1° 30′
0°	0·9920	0·7620	0·7620	0·7617	0° 30′

Sun-heat Formulæ.

Heat received per sq. unit, in unit of time is represented by

$$Ap^u \cos z.$$

A = the solar constant;
p = atmospheric absorption constant;
$u = \sqrt{2rh + h^2 + r^2 \cos^2 z} - r \cos z$;
z = sun's zenith distance;
h = height of atmosphere;
r = radius of earth;
$p = 0{\cdot}76$ (Pouillet).

(I.) To calculate u.—

$$u = r\sqrt{\cos^2 z + \frac{2h}{r} + \frac{h^2}{r^2}} - r \cos z.$$

If $h = 50$ miles, $\frac{h}{r} = \frac{1}{80}$.

Therefore,
$$u = 80\sqrt{\cos^2 z + \frac{1}{40}} - 80 \cos z;$$
$$u = 80\sqrt{\cos^2 z + 0{\cdot}025000} - 80 \cos z. \qquad (4)$$

(II.) To calculate p^u.—

$$p^u = 1 + \frac{(ku)}{1} + \frac{(ku)^2}{1\,.\,2} + \frac{(ku)^3}{1\,.\,2\,.\,3} + \&c.;$$

$$p = 0{\cdot}76.$$

Therefore, since $k = \log_e(p) = -0{\cdot}274$;

$$p^u = 1 - \frac{(0{\cdot}274u)}{1} + \frac{(0{\cdot}274u)^2}{1\,.\,2} - \frac{(0{\cdot}274u)^3}{1\,.\,2\,.\,3} + \&c.$$

Since u ranges from 1 to 12·65, this series does not converge rapidly enough, and it is usually better to obtain p^u directly, as follows:—

$$\log(p^u) = u \log p;$$
$$\log(p^u) = -u \times 0{\cdot}119. \qquad (5)$$

2°. The next step was to determine how long the sun remains in any zone of zenith distance, one degree in width, in the course of a year.

This was done, for the latitudes 0°, 30°, 60°, in the following manner; and although the calculations are not yet completed, involving as they do 300 folio sheets, enough has been accomplished to induce the Association to proceed with the calculations for other latitudes.

We here append the form of the tables used in computing the time spent by the sun in each zone, of one degree of width in zenith distance, and, as it would be a useless expenditure of money to print in full the details of the calculations, we propose to have two fair copies of the calculations prepared and bound together, one to be deposited in the library of Trinity College, Dublin, and the other placed at the disposal of the British Association.

A complete summary of the entire results will, of course, be printed in the *Proceedings* of the Association.

It will require an additional grant of 25*l.* to complete the calculations for the latitudes 0°, 30°, and 60°, and a grant of 50*l.* would enable us to complete the whole calculations for the latitudes 0°, 30°, 40°, 50°, and 60°.

The mean annual temperatures (as given by observations) between 0° and 30° are disturbed by the distribution of land and water, and the temperatures of latitudes above 60° rest upon insufficient data of observation; for which reasons we propose to limit our calculations to the latitudes above indicated.

III.—*Sun-heat Formulæ.*

Let h = sun's hour angle,
λ = latitude of place,
δ = sun's declination,
z = sun's zenith distance;

$$\cos h = \frac{\cos z \mp \sin\lambda \sin\delta}{\cos\lambda \cos\delta},$$

$$\cos h' = \frac{\cos z' \mp \sin\lambda \sin\delta}{\cos\lambda \cos\delta},$$

$h - h'$ = time of passing through the zone $(z - z')$,

degrees of arc being converted into minutes of time, as follows, $1° = 4^m$:

$$\sin\delta = \sin\Delta \sin l,$$

where l = sun's longitude,[1]
$l = \pm n \times 59'{\cdot}137$,
n = number of days from Equinox.
$\Delta = 23° 28'$.

Second Report of the Committee, consisting of Professor Sir WILLIAM THOMSON, Dr. MERRIFIELD, Professor OSBORNE REYNOLDS, Captain DOUGLAS GALTON, *and* Mr. J. N. SHOOLBRED (*Secretary*), *appointed for the purpose of obtaining information respecting the Phenomena of the Stationary Tides in the English Channel and in the North Sea; and of representing to the Government of Portugal and the Governor of Madeira that, in the opinion of the British Association, Tidal Observations at Madeira or other islands in the North Atlantic Ocean would be very valuable, with the view to the advancement of our knowledge of the Tides in the Atlantic Ocean.*

[PLATES II.—VIII.]

THIS Committee was appointed at the Plymouth meeting in 1877, to endeavour to arrange for, and to collect the results of a series of simultaneous tidal observations in the English Channel and in the North Sea; and also to impress upon the Portuguese Government the advantage which would accrue from the establishment of a station at Madeira for systematic and continuous tidal observations.

The Portuguese Government, having had this latter subject brought under their notice by Her Majesty's Foreign Office, readily fell in with the suggestion of the British Association; and a self-registering tide-gauge on Sir William Thomson's principle has been made by Messrs. White, of Glasgow. This instrument has been sent out to Madeira, for erection on the Loo Rock, in the Bay of Funchal, where it is hoped that it will soon be working satisfactorily. The entire cost of construction and of erection has been borne by the Portuguese Government, and the instrument remains, of course, in their hands.

The importance of an accurate knowledge of the tides at Dover in particular, in connection with those of the entire English Channel, being soon made evident to the Committee, as well as the great advantage which would ensue from the establishment of a self-registering tide-gauge at that place, the matter was brought by the Chairman under the notice of the Board of Trade; the request being further supported by the Lord Warden of the Cinque Ports, Earl Granville. The Board of Trade received the request most favourably, and consented to establish at their own expense a self-registering gauge, at a site some distance down the Admiralty Pier, where a tide-well had been made during the original construction of the pier; its connection with the water outside being at a level of twelve feet below the low water of ordinary spring tides. The gauge, embracing Sir William Thomson's latest improvements, has been constructed and erected by Messrs. A. Legé & Co., of London, under the

[1] It was found better, in practice, to take the sun's declination from day to day from the 'Nautical Almanac,' by which means the eccentricity of the earth's orbit was introduced.

direction of Mr. Edward Druce, C.E., the resident engineer in charge of the Admiralty Works at Dover. It will remain, of course, in the hands of, and under the control of the Board of Trade.

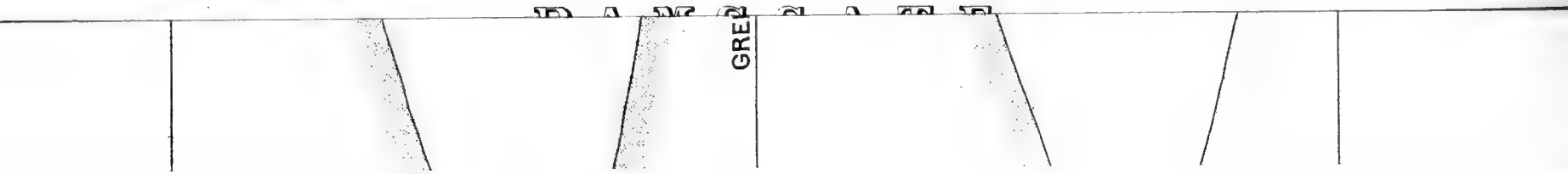
The Committee having secured for the simultaneous tidal observations in the English Channel and in the Irish Sea, their main duty, the hearty co-operation of the Admiralty, of the Board of Trade, of the French Minister of Public Works, as well as of the Minister of the same department in Belgium, and also of a number of private observers, both in this country and on the Continent, a programme of observations at different times during the spring and summer of 1878 was arranged, in accord with the different observers, a copy of which will be found in Appendix I. These simultaneous observations extended on the English side of the Channel from Portland to Yarmouth, while on the Continent they embraced the coast from Havre to the mouth of the North Sea Canal, leading up to Amsterdam.

Comparative tables are given in Appendix II., which show the times and the levels of the high waters and of the low waters at the different places, during the equinoctial tides observed in the month of March; which may be taken as typical of the two other months. They are all reduced to Greenwich time and to the level of twenty feet below the Ordnance datum of Great Britain. This is in accordance with the suggestion of the Committee on the Ordnance datum of Great Britain.[1] The level proposed as a datum of comparison for tidal observations of an international character, viz., '20 feet below the Ordnance datum of Great Britain,' is a point which practically coincides with '5·50 metres below the French Zero du Nivellement' (Bourdaloue), and with '12 feet 6 inches below the Ordnance datum of Ireland.' Some of the tidal curves from different points of observation are also appended; several distinctive peculiarities, such as double tides, &c., are exhibited in them. See Plates.

A careful consideration of the observations shows that on one point alone, that of tidal constants, much valuable information might be added to that already available, if a series of simultaneous observations, of a somewhat similar character to those just obtained, were carried out uninterruptedly, over a considerable period, of not less than twelve months, and over a large extent of coast. The Committee, however, feel that such a duty hardly falls within their province. They beg to suggest that, possibly at some future time, this subject might be entrusted to some suitable body; the more so, that the basis of the means of obtaining the necessary observations is already furnished by the labours of this Committee, with a considerable extension, however, in the number of points of observation.

Before concluding their labours, the Committee request that the thanks of the British Association be conveyed to the First Lord of the Admiralty, the President of the Board of Trade, the French Minister of Public Works, the Belgian Minister of Public Works, and to the several other authorities and private individuals, both in this country and on the Continent, who have kindly and gratuitously had the various observations carried out and communicated to this Committee; and more especially would they beg to thank the French Association for the Advancement of Science for its cordial assistance in supporting the proposal of the British

[1] See p. 219 of the present volume.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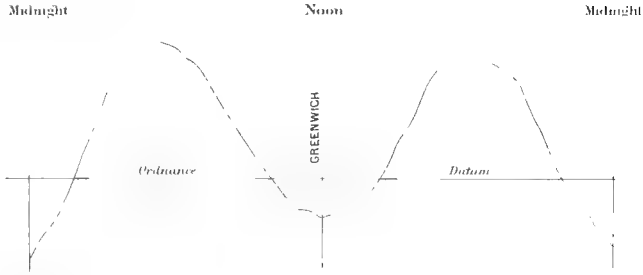
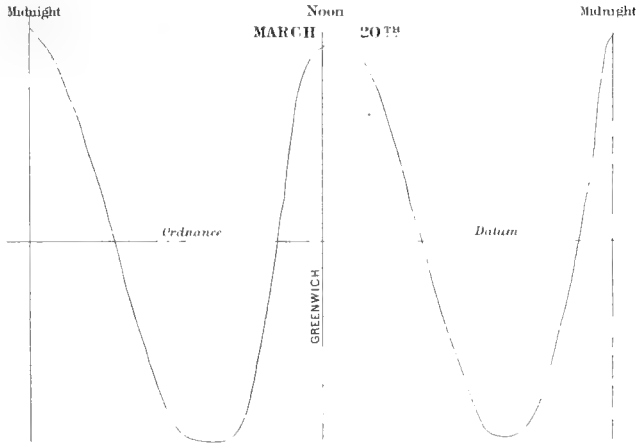
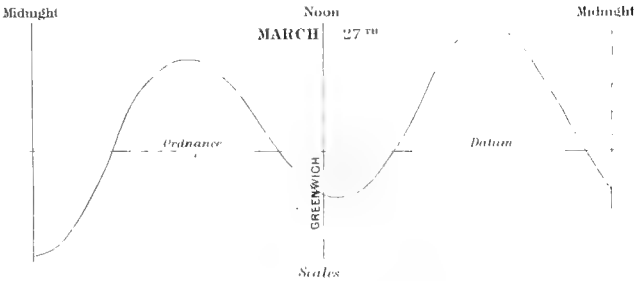
MARCH 13TH 1878



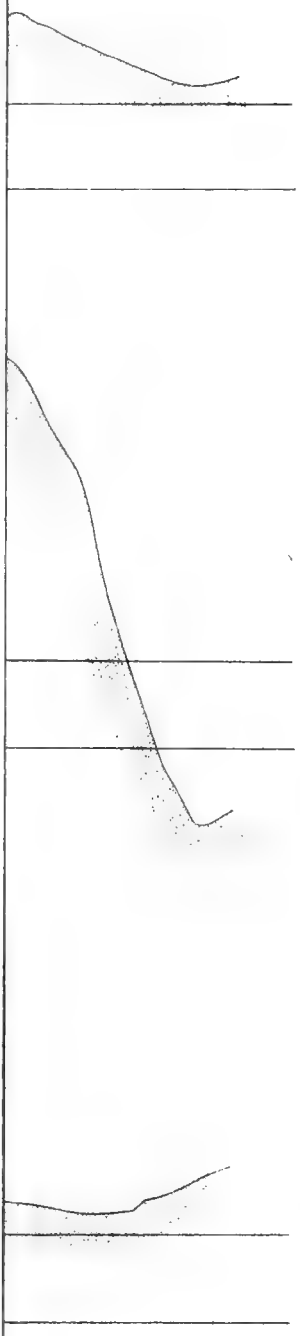




Scales

Vertical as { 1 Inch = 4 Feet / 0·0209m = 1 Metre — *Horizontal* { 1 Inch 1 Hours / 0·076m 13 Hours

Illustrating the 2nd Report of the Committee on the Phenomena of Stationary Tides in the English Channel



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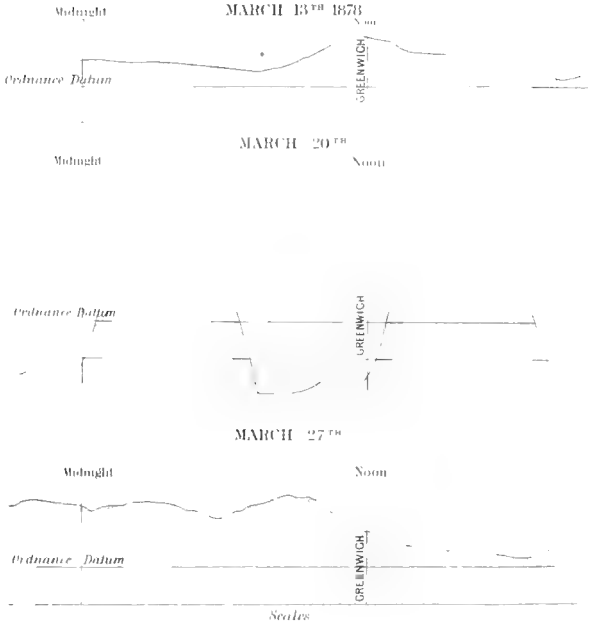

Illustrating the 2nd Report of the Committee on the Phenomena of Stationary Tides in the English Channel

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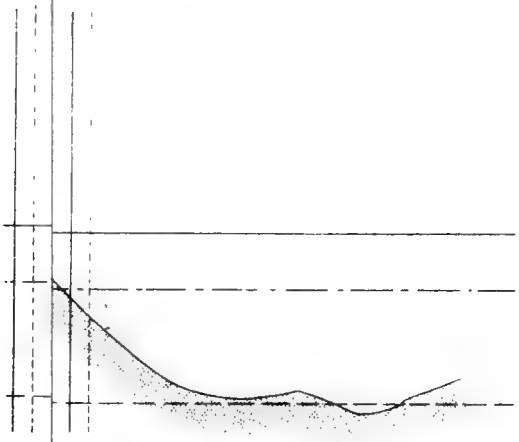

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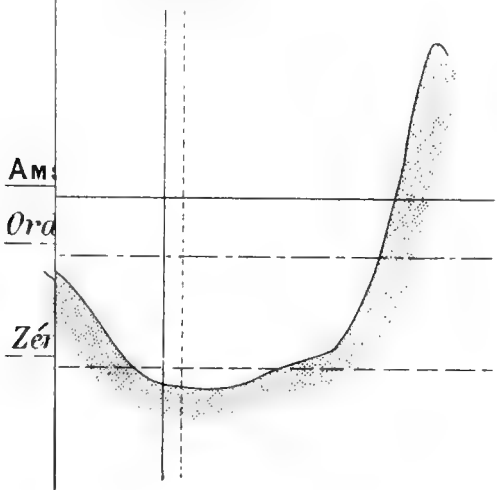

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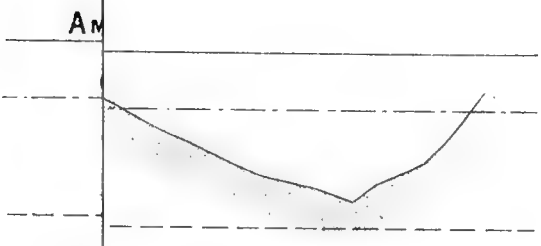

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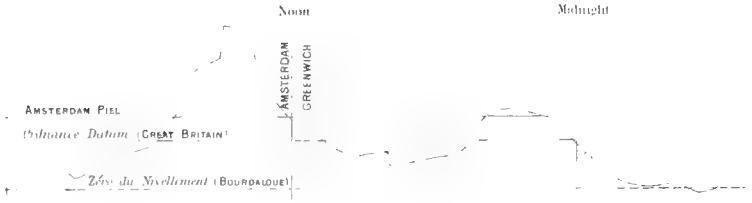

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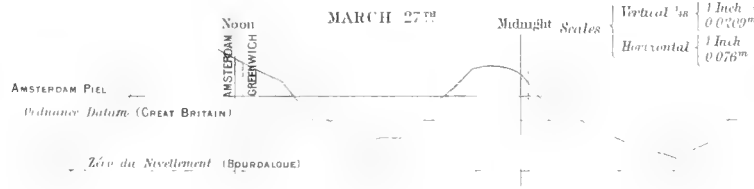

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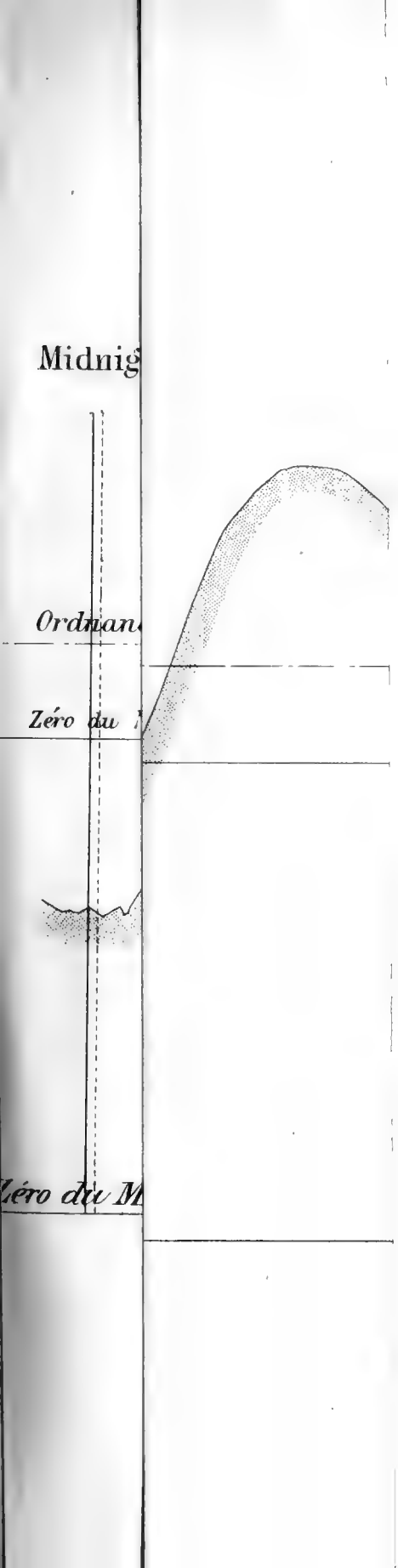
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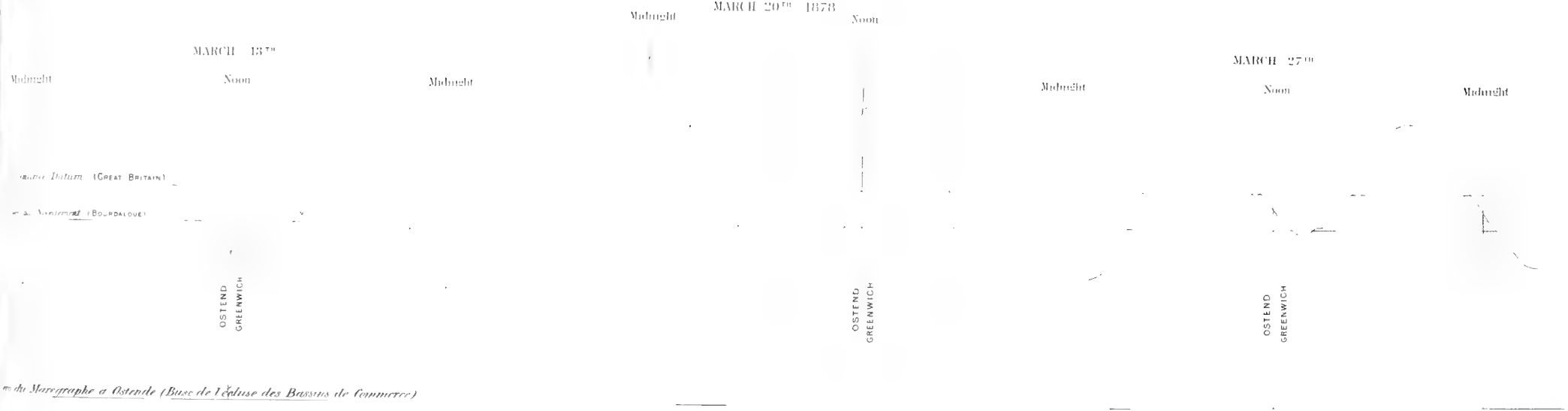

du Marégraphe à Ostende (Buse de l'écluse des Bassins de Commerce)

Scales

Vertical 1/48 = 1 Inch = 1 Feet / 0.0209m = 1 Metre Horizontal 1 Inch = 4 Hours / 0.076m = 12 Hours

Illustrating the 2nd Report of the Committee on the Phenomena of Stationary Tides in the English Channel

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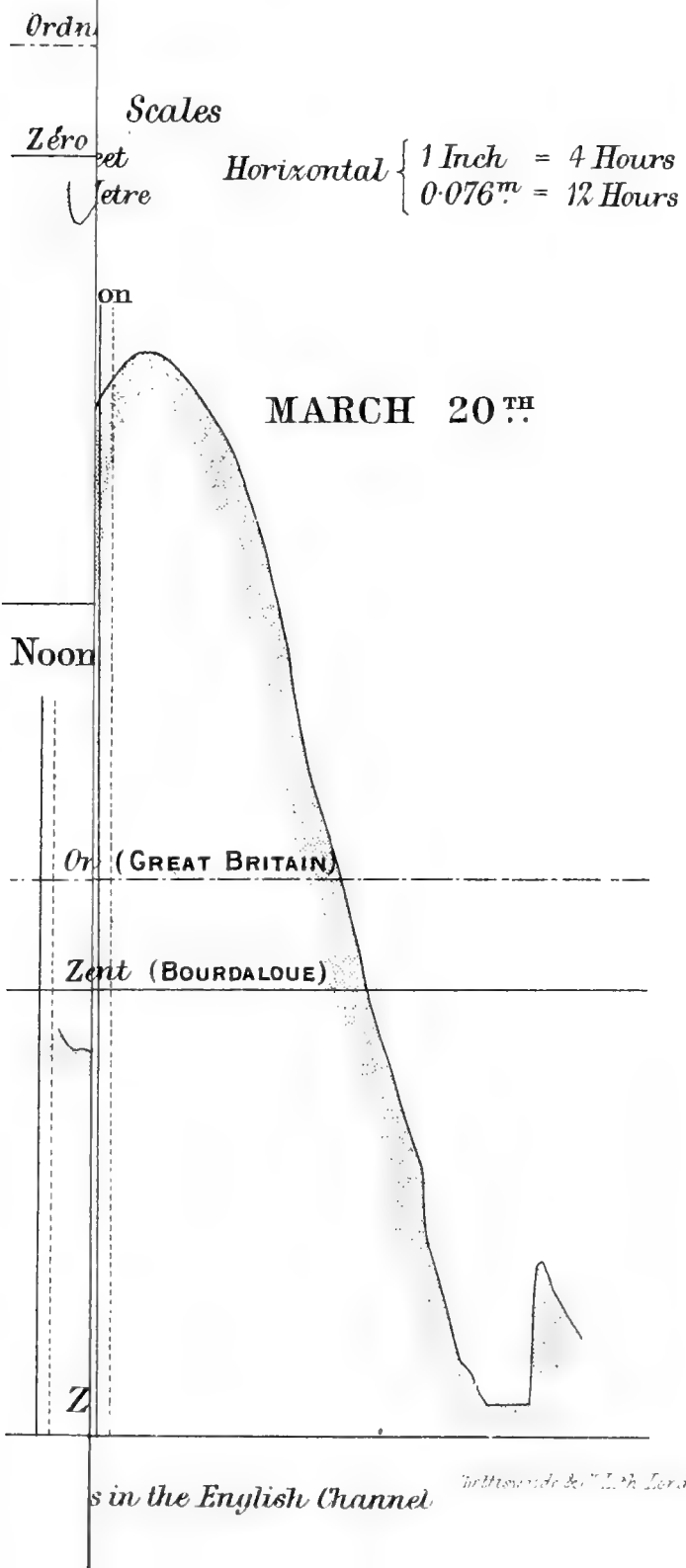

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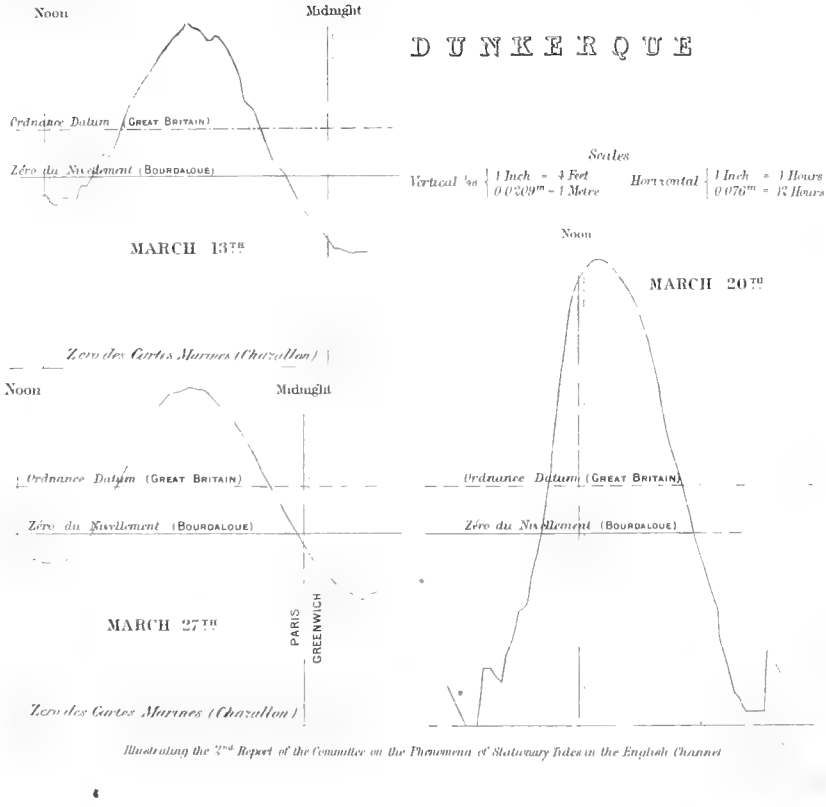

Illustrating the 2nd Report of the Committee on the Phenomena of Stationary Tides in the English Channel

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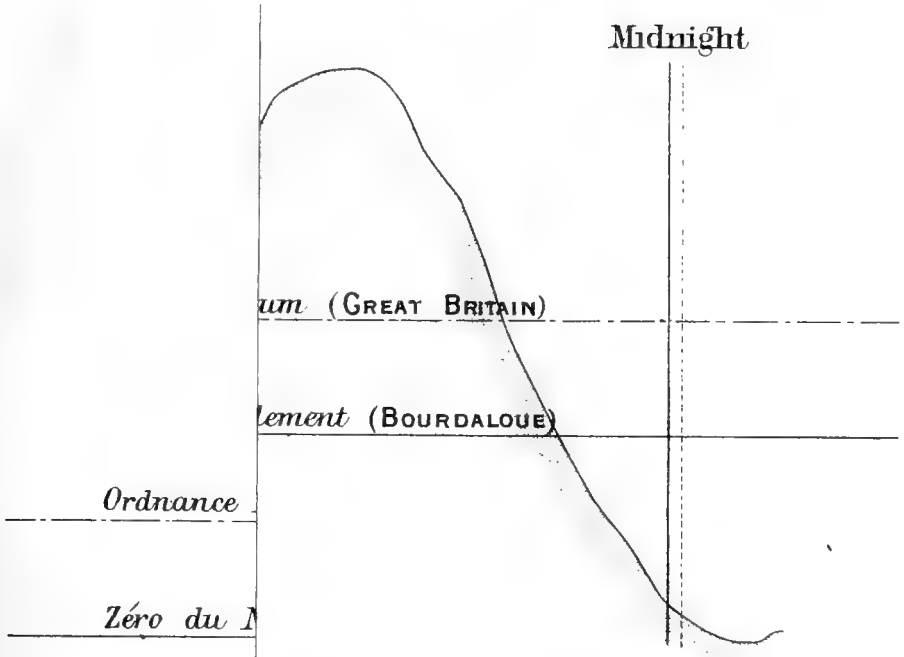

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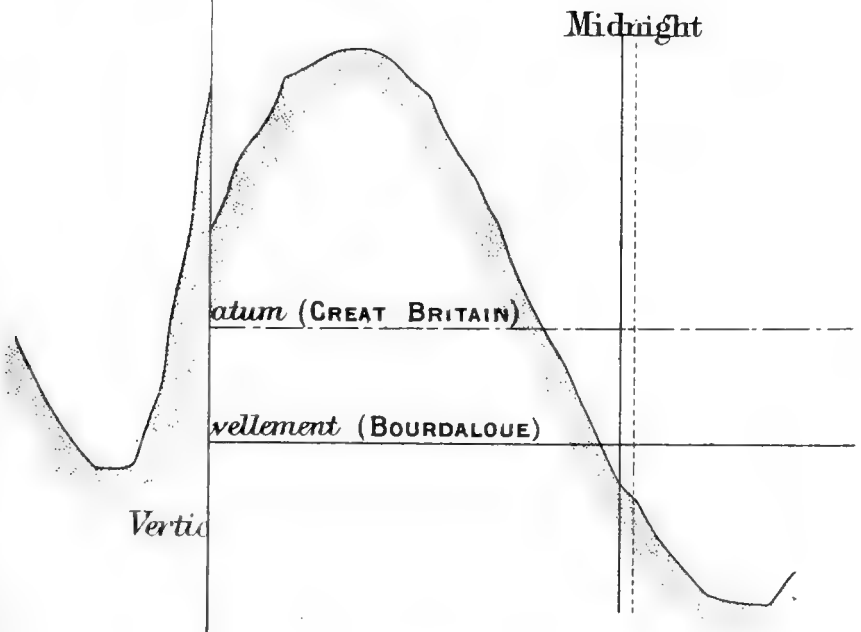

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he English Channel

CALAIS

MARCH 20TH

Noon

Ordnance Datum (GREAT BRITAIN)

Zero du Nivellement (BOURDALOUE)

PARIS

GREENWICH

MARCH 13TH 1878

Noon

Midnight

PARIS

GREENWICH

Ordnance Datum (GREAT BRITAIN)

Zéro du Nivellement (BOURDALOUE)

MARCH 27TH

Noon

Midnight

Ordnance Datum (GREAT BRITAIN)

Zéro du Nivellement (BOURDALOUE)

PARIS

GREENWICH

Scales

Vertical $\frac{1}{48}$ { 1 Inch = 4 Feet; 0·0209m = 1 Metre

Horizontal { 1 Inch = 4 Hours; 0·076m = 12 Hours

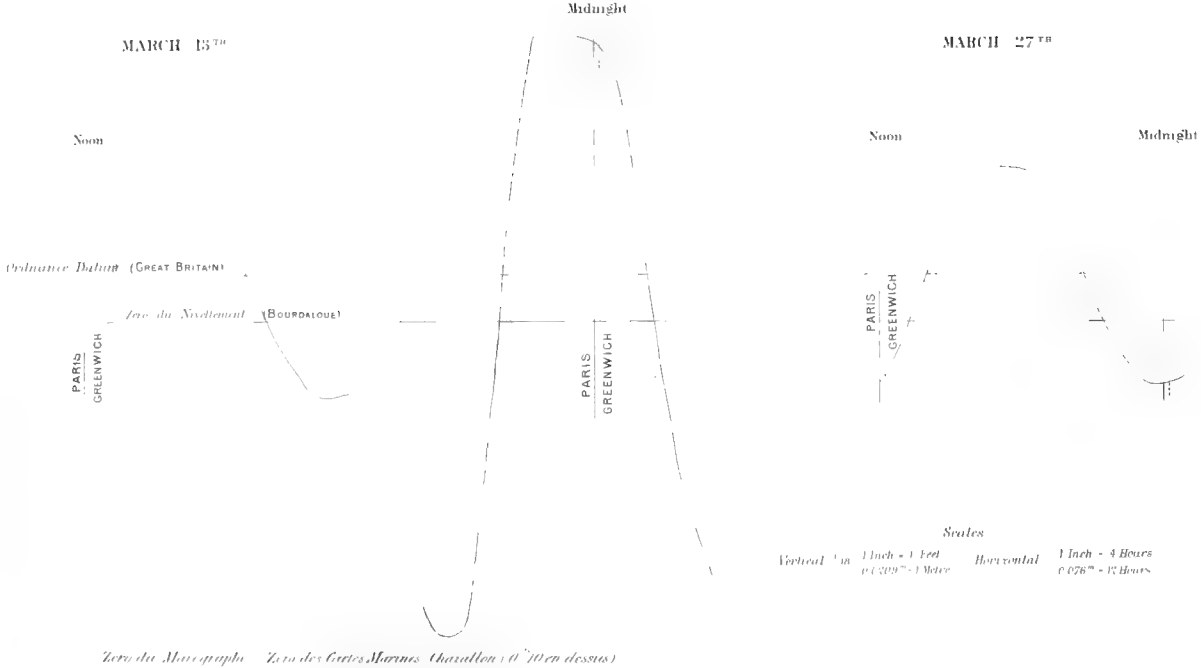
Illustrating the 2nd Report of the Committee on the Phenomena of Stationary Tides in the English Channel

NATURAL HISTORY

Tides in

HAVRE

MARCH 20TH 1878



Illustrating the 2nd Report of the Committee on the Phenomena of Stationary Tides in the English Channel

Association, and in urging it upon the French Minister of Public Works. The Committee beg to report that the 10*l.* granted to it for expenses in connection with the collection and the reduction of the tidal observations has been expended.

Appendix I.—PROGRAMME OF OBSERVATIONS.

Tides in the English Channel and in the North Sea. Observations to be taken in 1878.

1. Observations every quarter of an hour, from Low Water to Low Water.

Tide.	Time of H.W. (at Dover).	
Feb. 12	5.46 afternoon.	The observations to commence one hour before the first L.W. and to finish one hour after the last L.W. of each tide.
„ 19	0.31 „	
„ 26	6.37 „	
March 13	5.23 „	The exact time of H.W. and of L.W. to be noted; the other observations to be at each exact quarter of an hour (by the clock).
„ 20	0.2 „	
„ 27	6.16 „	
April 11	5.12 „	Greenwich mean time to be kept throughout.
„ 18	11.35 „	
„ 25	5.39 „	

2. Observations as to the times and heights of H.W. and L.W. only.

In June	On the morning tides, from	10th	to	16th	inclusive.
	„ „ afternoon „	„	„ 17	„ 24	„
In August	„ „ morning „	„	„ 8	„ 14	„
	„ „ afternoon „	„	„ 15	„ 23	„

N.B.—At each place the zero of the tide gauge must be connected with the Datum of the Ordnance Survey of Great Britain. The condition of the barometer, of the direction and force of the wind, to be observed from time to time.

Points for Tidal Observations.

Yarmouth.	Dungeness.	North Sea Canal Entrance.	Boulogne.
Lowestoft.	Hastings.	Flushing.	Tréport.
Harwich.	Brighton.	Ostend.	Dieppe.
Sheerness.	Shoreham.	Dunkerque.	St. Valery en Caux.
Ramsgate.	Ventnor.	Calais.	Fécamp.
Dover.	Portland.		Havre.

APPENDIX II.—SIMULTANEOUS TIDAL OBSERVATIONS IN THE ENGLISH CHANNEL AND IN THE NORTH SEA, Taken on March 13, 20, and 27, 1878.

ENGLISH SIDE.

Place of Observation	Equinoctial Neap			Equinoctial Spring			Equinoctial Neap		
	Time	Heights	Reduced	Time	Heights	Reduced	Time	Heights	Reduced
		ft. in.	feet		ft. in.	feet		ft. in.	feet
Yarmouth Bar	12th, 7.0 p.m.	1 9 L.W.	17·86	20th, 2.6 a.m.	−1 3 L.W.	14·86	26th, 8.30 p.m.	0 9 L.W.	16·86
	13th, 2.31 a.m.	5 11 H.W.	22·03	,, 9.54 ,,	5 9 H.W.	21·86	27th, 3.25 a.m.	4 3 H.W.	20·36
	,, 8.30 ,,	3 9 L.W.	19·86	,, 4.0 p.m.	−0 10 L.W.	15·28	,, 10.0 ,,	2 6 L.W.	18·61
	,, 3.13 p.m.	6 2 H.W.	22·28	,, 10.15 ,,	6 9 H.W.	22·86	,, 4.9 p.m.	5 6 H.W.	21·61
	,, 9.0 ,,	1 5 L.W.	17·53	21st, 4.40 a.m.	−1 0 L.W.	15·11	,, 10.10 ,,	1 2 L.W.	17·28
Lowestoft	,, 9.52 a.m.	15 2½ L.W.	21·71	20th, 4.30 ,,	9 6½ L.W.	16·04	,, 9.45 a.m.	14 6 L.W.	21·00
	,, 3.37 p.m.	17 8½ H.W.	24·21	,, 10.37 ,,	17 4 H.W.	23·83	,, 4.0 p.m.	17 1½ H.W.	23·62
	,, 10.52 ,,	12 8 L.W.	19·17	,, 4.30 p.m.	10 10½ L.W.	17·38	,, 11.7 ,,	12 10 L.W.	19·33
Harwich	,, 11.37 a.m.	7 4 L.W.	20·33	,, 6.30 a.m.	1 3 L.W.	14·25	,, 11.30 a.m.	6 11 L.W.	19·92
	,, 6.22 p.m.	12 6 H.W.	25·50	,, 12.55 p.m.	15 0 H.W.	28·00	,, 6.25 p.m.	12 1½ H.W.	25·13
	,, 11.22 ,,	4 10½ L.W.	17·88	,, 6.45 ,,	2 4 L.W.	15·33	28th, 1.22 a.m.	5 2½ L.W.	18·21
Sheerness	,, 0.30 ,,	−3 0 L.W.	18·44	,, 8.0 a.m.	−10 8 L.W.	10·77	27th, 0.15 p.m.	−6 6 L.W.	14·90
	,, 7.0 ,,	4 5 H.W.	25·86	,, 1.35 p.m.	8 4 H.W.	29·77	,, 7.30 ,,	4 1 H.W.	25·52
	—	—	—	,, 8.0 ,,	−9 8 L.W.	11·77	—	—	—
Ramsgate	,, 5.20 a.m.	17 6 H.W.	—	,, 7.35 a.m.	3 2 L.W.	11·45	,, 6.30 a.m.	15 8 H.W.	—
	,, 11.55 ,,	10 2 L.W.	18·45	,, 12.40 p.m.	20 3 H.W.	28·52	,, 12.22 p.m.	9 9 L.W.	18·03
	,, 5.25 p.m.	17 1½ H.W.	25·41	,, 7.22 ,,	3 6 L.W.	11·78	,, 6.52 ,,	17 3 H.W.	25·53
Dover	,, 12.20 ,,	6 0 L.W.	17·30	,, 7.0 a.m.	−2 3 L.W.	9·05	,, 1.16 a.m.	6 0 L.W.	17·30
	,, 5.20 ,,	14 2 H.W.	25·47	,, 12.0 noon	19 2 H.W.	30·47	,, 5.32 ,,	12 11 H.W.	24·22
	—	—	—	,, 7.25 p.m.	−2 3 L.W.	9·05	—	—	—
Newhaven	,, 5.15 ,,	14 5 H.W.	26·39	,, 12.10 ,,	21 2 H.W.	33·14	,, 6.0 p.m.	15 5 H.W.	27·39
	—	—	—	—	—	—	—	2 10 L.W.	15·08
Shoreham	,, 4.34 ,,	11 6 H.W.	23·75	,, 11.49 a.m.	18 3 H.W.	30·50	,, 5.24 ,,	13 0 H.W.	25·25
Portland	,, 7.25 a.m.	2 1½ L.W.	20·55	19th, 11.7 p.m.	−1 2½ L.W.	17·22	,, 5.40 a.m.	3 6½ L.W.	21·97
	,, 11.37 ,,	8 7 H.W.	22·01	20th, 3.45 a.m.	6 10 H.W.	25·26	,, 8.38 ,,	4 6 H.W.	22·93
	,, 8.15 p.m.	1 10 L.W.	20·26	,, 11.15 ,,	−1 2 L.W.	17·26	,, 6.45 p.m.	1 11½ L.W.	20·39

FRENCH SIDE

Place of Observation	Equinoctial Neap			Equinoctial Spring			Equinoctial Neap		
	Time	Heights	Reduced	Time	Heights	Reduced	Time	Heights	Reduced
		feet	feet		feet	feet		feet	feet
Amsterdam Ship Canal at North Sea Harbour	13th, 2.40 a.m.	3·63 L.W.	18·59	20th, 0.40 a.m.	3·86 L.W.	18·82	27th, 4.55 a.m.	3·04 L.W.	18·00
	„ 8.50 „	9·77 H.W.	24·73	„ 3.30 „	8·95 H.W.	23·91	„ 8.40 „	8·62 H.W.	23·58
	„ 3.50 p.m.	4·02 L.W.	18·98	„ 11.50 „	1·73 L.W.	16·69	„ 5.10 p.m.	4·19 L.W.	19·15
	„ 8.40 „	6·32 H.W.	21·28	„ 4.0 p.m.	8·95 H.W.	23·91	„ 10.40 „	7·31 H.W.	22·27
	14th, 4.40 „	2·98 L.W.	17·94	21st, 0.40 a.m.	2·78 L.W.	17·74	28th, 6.20 a.m.	3·50 L.W.	18·46
Flushing	13th, 6.30 a.m.	5·22 H.W.	26·20	20th, 8.20 „	−8·04 L.W.	12·95	27th, 7.35 „	4·26 H.W.	25·25
	„ 1.0 p.m.	−3·12 L.W.	17·87	„ 2.10 p.m.	7·85 H.W.	28·82	„ 2.35 p.m.	−2·56 L.W.	18·52
Ostend	12th, 11.28 p.m.	6·17 L.W.	14·33	19th, 7.3 „	4·66 L.W.	12·82	„ 1.8 a.m.	7·05 L.W.	15·22
	13th, 6.9 a.m.	15·42 H.W.	23·58	20th, 0.25 a.m.	20·60 H.W.	28·77	„ 7.40 „	16·04 H.W.	24·21
	„ 0.8 p.m.	7·54 L.W.	15·71	„ 7.40 „	3·05 L.W.	11·22	„ 1.56 p.m.	9·58 L.W.	17·74
	„ 6.55 „	14.50 H.W.	22·66	„ 1.3 p.m.	20·27 H.W.	28·44	„ 7.40 „	15·81 H.W.	23·98
	„ 1.28 a.m.	5.28 L.W.	13·45	„ 7.43 „	3·94 L.W.	12·10	28th, 2.43 a.m.	7·81 L.W.	15·97
Dunkerque	„ 1.5 „	6·56 L.W.	16·67	„ 7.20 a.m.	0·00 L.W.	10·11	27th, 1.5 p.m.	6·73 L.W.	16·83
	„ 5.50 „	14·27 H.W.	24·38	„ 12.42 p.m.	19·19 H.W.	29·30	„ 7.5 „	13·94 H.W.	24·05
	14th, 0.50 a.m.	4·72 L.W.	14·83	„ 7.12 „	0·49 L.W.	10·60	28th, 2.12 a.m.	5·25 L.W.	15·36
Calais	13th, 11.52 „	−2·23 L.W.	15·81	„ 7.13 a.m.	−10·50 L.W.	7·55	27th, 12.55 p.m.	−1·80 L.W.	16·24
	„ 5.46 p.m.	6·40 H.W.	24·44	„ 12.23 p.m.	12·99 H.W.	31·04	„ 6.56 „	6·89 H.W.	24·94
	14th, 0·40 a.m.	−3·61 L.W.	14·44	„ 7.33 „	−10·17 L.W.	7·87	28th, 1.49 a.m.	−2·79 L.W.	15·26
Boulogne	13th, 11.50 „	41·67 L.W.	14·50	„ 7.35 a.m.	32·94 L.W.	5·77	27th, 12.35 p.m.	42·39 L.W.	15·22
	„ 5.13 p.m.	52·23 H.W.	25·07	„ 12.20 p.m.	61·62 H.W.	34·45	„ 6.20 „	53·32 H.W.	26·15
	14th, 0.21 a.m.	41·08 L.W.	13·91	„ 7.50 „	32·78 L.W.	5·61	28th, 1.35 a.m.	41·92 L.W.	14·76
Tréport	13th, 11.20 „	10·63 L.W.	14·86	„ 6.19 a.m.	0·20 L.W.	4·43	27th, 12.20 p.m.	10·66 L.W.	14·90
	„ 5.5 p.m.	21·65 H.W.	25·89	„ 11.53 „	33·40 H.W.	37·63	„ 6.0 „	22·80 H.W.	27·04
	14th, 0.20 a.m.	9·68 L.W.	13·91	„ 6.50 p.m.	0·00 L.W.	4·23	28th, 1.20 a.m.	10·50 L.W.	14·73
Dieppe	13th, 10.48 „	10·50 L.W.	14·73	„ 6.11 a.m.	0.66 L.W.	4·89	27th, 11.45 „	9·84 L.W.	14·07
	„ 4.45 p.m.	20·51 H.W.	24·74	„ 11.45 „	32·09 H.W.	36·32	„ 6.0 p.m.	22·54 H.W.	26·77
	„ 11·33 „	10·66 L.W.	14·90	„ 6.29 p.m.	0·52 L.W.	4·76	28th, 0.41 a.m.	10·83 L.W.	15·06
Havre	„ 9.35 a.m.	10·89 L.W.	14·53	„ 5.33 „	1·25 L.W.	4·89	27th, 10.31 „	10·93 L.W.	14·57
	„ 3.20 p.m.	19·16 H.W.	22·80	„ 9.48 „	26·74 H.W.	30·38	„ 5.16 p.m.	20·77 H.W.	24·41
	„ 10.20 „	11·16 L.W.	14·80	21st, 5.48 a.m.	1·31 L.W.	4·95	„ 11.46 „	11·71 L.W.	15·35

NOTE.—The time throughout is that at Greenwich. In the column headed 'reduced,' the heights are given in feet above a level 20 feet below the Ordnance Datum of Great Britain.

Report of Observations of Luminous Meteors during the year 1878–79, *by a Committee consisting of* JAMES GLAISHER, *F.R.S.*, *&c.*, R. P. GREG, *F.G.S.*, *F.R.A.S.*, C. BROOKE, *F.R.S.*, Professor G. FORBES, *F.R.S.E.*, WALTER FLIGHT, *D.Sc.*, *F.G.S.*, *and* Professor A. S. HERSCHEL, *M.A.*, *F.R.A.S.* (*Reporter*).

THE Committee regrets to record the loss during the past year, by Mr. Greg's retirement from active work with the Committee and by Mr. Brooke's death, of two most active supporters among its members. By adding to its list the names of two observers, Mr. E. J. Lowe and Professor R. S. Ball, who have distinguished themselves very greatly by their contributions to this branch of astronomy, and who have consented to take part in the Committee's further operations, it is hoped to repair the present loss of excellent counsel and assistance which the limited numbers of the Committee have unexpectedly sustained.

From the loss of Mr. Greg's assistance, and also to limit the extent of this year's Report to an ordinary and reasonable length, it has been resolved to defer for discussion until a later Report the particulars of observations of meteor showers, annual and occasional, which have been received during the past year, and the papers and discourses on the connections of cometary with meteor-hypotheses that have been published and circulated during the same time. The expected return of Biela's comet to its perihelion in the present year, leading a shower of shooting-stars to be looked for on November 27 next, with much confidence among astronomers, will afford an occasion next year to return to this subject and to review together the parallel results obtained in the two successive years of observations on meteor showers of ordinary and extraordinary occurrence; of the Andromedes in November last, however, nothing was visible, and very unfavourable weather has generally caused only very meagre views of the annual star showers of October, December, January, and April last (and also of the major showers of August in this year and last) from being seen.

The main Appendices of this Report, following a table of occurrences of occasional phenomena of fireballs, review the discussions by different authors of a great number of doubly observed fireballs recorded for a few years past, describing the results and the views regarding them to which the authors have been led by their reductions. Of these fireballs conspicuous detonating ones occurred in the United States on August 11 and December 30, 1878, and on January 28 (a.m.), 1879; in Bohemia and Saxony on January 12, 1879; and in England on February 22 and 24 (a.m.), 1879, the real paths of all of which have, to a greater or less degree of certainty and closeness, been approximately ascertained.

The pages of a few lists of meteor shower observations and reductions furnished by Mr. Greg and Mr. Denning are also given in an Appendix. The rest of the Report consists of the review of recent aërolitic occurrences and investigations by Dr. W. Flight. The falls of two aërolites during the past twelve or fifteen months are described in this review; at Tieschitz, Moravia, on July 15, 1878 (a single stone), and at Esterville, Iowa, U.S., on May 10, 1879. The last of these stonefalls was of unexampled magnitude, one stone which fell weighing 500 lbs., and the other fragments which have been found, together amounting also

to a considerable weight. The historical review of researches on meteorites during the past year, which this last appendix of the Reports contains, is also throughout of very particular and valuable interest.

Appendix I.

Notes of Meteors and Fireballs doubly observed.

The following double observations of shooting-stars were obtained by Mr. Denning and Mr. Corder, during nights of simultaneous watch at Bristol and Writtle, near Chelmsford, in October and November last.

Date, 1878	Hour, Approx. G.M.T.	Place of Observation	Appar. Size as per Stars	Apparent Path from α	from δ	to α	to δ	Radiant Point of the projected Paths α	δ	By nearest Stars
	h. m.			°	°	°	°	°	°	
Oct. 24	12 25 a.m.	Bristol	5th mag.	107	+13	110	+20	98	−12	Near θ Canis Majoris
		Writtle	2nd mag.	54	+23	32	+35			
Oct. 24	12 45 a.m.	Bristol	2nd mag.	133	+23	144	+25	86	+6	Near α Orionis
		Writtle	2nd mag.	131	+48	141	+52			
Nov. 18	9 50 p.m	Bristol and Writtle	See descriptions of the meteor in the accompanying general fireball list.							

Only the resulting radiant-points of the first two of these meteors, obtained from projections of their apparent paths, have yet been determined. The real path of the last meteor, which was a small fireball, vertical over Brittany, in the western part of France, will be found described in the accompanying table which exhibits a list of such results, continued from similar lists in the last three years' Reports, of meteor heights, &c., which have been recently determined. The following notes include remarks and some further observations of these fireballs in addition to those accounts of them which are given in detail in the general fireball list of this report.

Path of the meteor of 1868, September 5, $8^h\ 35^m$ p.m. Berne time ($8^h\ 5^m$ p.m., G.M.T.), by G. von Niessl.[1] This large fireball (see these Reports, vol. for 1869, p. 226) was widely and well observed at many places in France and Switzerland, and in Germany and Italy; and some accounts of it have already been submitted to calculation by M. Tissot,[2] who places the end-point 192 miles over Mettray, near Tours, in France. The point of first visibility and nearest approach to the earth of M. Tissot's track, is 70 miles over Belgrade, in Servia, and the meteor's geocentric velocity was 55 miles per second, corresponding to a heliocentric velocity of 95 miles per second. While horizontal at Belgrade, this is an ascending course, inclined upwards at an angle of 14° to the horizon of Mettray, where the meteor disappeared, and these are results which appear to require more complete demonstration before they can be finally adopted. Professor Weilermann[3] also obtained from a

[1] *Verhandlungen des Naturforschenden Vereins in Brünn*, vol. xvii. Excerpt of 16 pp. from the author.

[2] *Comptes Rendus*, vol. lxix. p. 326. See these Reports, vol. for 1869, p. 272.

[3] Heis' *Wochenschrift für Astronomie*, vol. for 1869, p. 153.

rough apparent end-point of the meteor's path at Clermont Ferrand, in France, combined with observations of its course at Zürich, and at several other Swiss places, a terminal height of its flight, 102 miles over Chatillon sur Loire, a position which is to the east of Tours, but perhaps nearly the real height at which the meteor's disappearance actually took place.

Professor von Niessl has discussed a collection of well-recorded accounts of the meteor, including those used by Tissot and Weilermann and two described in these Reports (*sup. cit.*) at Puy de Sancy and Geneva, and newspaper accounts, with less precise descriptions, preserved in Continental journals.

As seen at the Zürich Observatory, and also at a neighbouring place in Switzerland, the fireball shot overhead, or a little south of the zenith, from close to Jupiter near the east horizon, to near Arcturus in the west. At Geneva and Morges, on the Lake of Geneva, it shot on a similar course close past the star η Ursæ Majoris, half-way thence to the W.N.W. horizon. French accounts state that at places in Côte d'Or, and near Tours, it passed overhead in the latter part of its flight; and that it was first seen at Trémont (Saone et Loire) rising upwards in the same field of view with the planet Jupiter, in a telescope. At Puy de Sancy the end of its course was exactly at β Ursæ Majoris. At Mayence, in Germany, it traversed the head of Capricornus, the Milky Way, and Ophiuchus to near the S.W. horizon under α Serpentis. Its course as seen at Bergamo, in Italy, by Zezioli, was from $17°+3°$ (5° or 6° left of Jupiter) to a point between Coma and Arcturus at $202°+27°$, the duration of its flight, as there observed, along this long path, being 17 seconds. These were all the positions noted by the stars exactly enough to be available for calculation.

The observations of the end-point give a height of 115 miles (imperfectly defined between 70 and 140 miles) over a point very clearly indicated near Vendôme, about 30 miles N.N.E. from Tours. Using the point so found to complete the Mayence observation, and projecting that and the other apparent paths by their most carefully recorded points, Professor von Niessl found as a well-defined place of the radiant-point a position at $13°{\cdot}9-2°$, about 6° south of Jupiter's apparent place.

The fact that several views of the meteor's first visibility in France, Switzerland, and Italy all describe it as having first made its appearance very close to the planet Jupiter, plainly indicates a very long course of the meteor's flight before it approached the region of the Alps. Upon a map the course passes backwards about 20 miles north of Belgrade towards the south coast of the Black Sea, and at a point 460 miles above a point near this latter coast, a little west of Sinope, the lines of sight of the meteor's first appearance at Zürich, Morges, and Bergamo intersect each other. But the parallax which even the base-line of Zürich and Bergamo (two places 130 English miles apart) offer of this point, is scarcely more than 5°. To assume it to be truly the exact place of the meteor's first appearance, would, it might certainly be contended, be reposing too much confidence in observers' first impressions of the earliest point of this long-flighted and rarely splendid meteor's apparition, in a part of its course too, where their descriptions, if accurate, should necessarily have represented the meteor as appearing to them to remain nearly stationary for several seconds.

If, with M. Tissot, we suppose the meteor to have first made its

appearance over the neighbourhood of Belgrade, its height at that point, on the course assigned to it by Professor von Niessl, would be 260 miles, and the total length of its nearly horizontal course was close upon 1200 miles! From the above point of geometrical intersection of the lines of sight, however, the entire length of course is about 1780 miles.

Professor von Niessl observes that a more southern track, with the same radiant-point, but with a lower termination, 104 miles over Ozaine, near Tours, passing backwards over Belgrade, and thus within 8 or 10 miles of the long course assigned to it by M. Tissot, agrees rather better than the calculated one with the general descriptions. The observer's view (Mr. B. F. Smith's) at Puy de Sancy, of the end of the meteor's course, 'exactly at β Ursæ Majoris,'[1] gives an end-height, it should be noticed, over Tours, of only 70 miles. But even with this minimum elevation, and with heights over the neighbourhood of Zürich, 400 miles from the place of extinction, variously given by observations as between 105 and 150 miles, the height over Belgrade, if we assume the meteor's course to have been rectilinear, and to have begun so soon, cannot have been less than 220 miles.

Performed in 17 seconds (the time of flight observed at Bergamo by Zezioli), the course of 1200 miles from Belgrade implied a velocity of 70 miles per second. Four other observed durations varied from 12 seconds at Clermont Ferrand to two minutes at Zürich, and the average duration from the five accounts, of 42 seconds, gives with the same course a velocity of 29 miles per second. Some 30 or 80 miles of the course ('20° or 30°') were again described by Mr. E. Jones as the meteor's rate of motion 'per second' at Geneva; and about 120 miles of the terminal part were observed at Puy de Sancy to be traversed in 4 or 5 seconds, giving a velocity of 25 or 30 miles per second. The parabolic speed of a meteor having the same radiant-point as that which Professor von Niessl has obtained of this large fireball would be 26 miles per second. But the evidence relating to the meteor's real velocity is scarcely certain enough to allow it to be made a subject of useful speculation in comparison with any theoretical parabolic or other orbital velocity.

It seems probable from this discussion that the fireball passed in the brightest part of its course from about 130 miles over the Lake of Zürich to not much less than 100 miles over the neighbourhood of Tours, crossing the Jura range, and the Swiss and French plains near it at a great height for a distance of 400 miles. An equal distance at least, if not a still larger one, was traversed by the meteor along the valley of the Drave, from a height of little less than 250 miles, near, or in the direction of Belgrade, before crossing the range of Tyrolese Alps about that river's source, and entering Switzerland near the Brenner pass. Professor von Niessl confines himself to presenting the much more startling results obtained directly from exact comparisons of the most precise descriptions; and by clearly deducing the radiant-point, and fully establishing the meteor's great height, he, in the main, confirms M. Tissot's track, while yet showing that it was almost exactly horizontal at Tours, where the meteor disappeared, instead of at its first origin at Belgrade, as M. Tissot had supposed.

1873, December 24, $7^h\ 39^m$ p.m. (Washington Mean Time). Detonating fireball.—A Committee of the Philosophical Society of Washington

[1] This star is supposed by Professor von Niessl to have perhaps been accidentally mistaken for the upper one, α of the two 'pointers' in Ursa Major.

was appointed immediately after the occurrence of this unusually large fireball to collect accounts of its appearance, and to submit them to a scientific discussion. Professor Cleveland Abbe, the Secretary of the Committee, describes in this Report[1] the delay which arose in its publication from the conflicting nature of the particulars furnished by observers of the meteor in the different accounts, together with a hope that a search conducted near the point of disruption of the meteor which these accounts had fairly established by the enquiries during the year 1874, might be rewarded by the discovery of some fragments of its substance. But this hope not having during the following three years been realised, the Report containing the observations and some results of their comparison together has no longer been withheld.

The fireball passed from about N.E. to S.W. nearly over Washington, with an intense illumination of the streets and houses of the town to a point so near the horizon (not more than 5° altitude), as in general to have been lost sight of behind buildings while still continuing its course. Professor Holden observed the terminal point at the U.S. Naval Observatory at altitude 4°45′, 22° S. from W. Accounts of its first appearance at Washington are much less certain and precise. Professors Newton, Hilgard, and Baird heard the explosion indoors at an interval after the light-flash which they noted variously as $1\frac{1}{2}$–3 minutes, corresponding to a distance of the meteor's track, at its nearest point, of 18 to 36 miles from Washington. The explosion was a 'bang' or loud report, shaking doors, windows, and the earth, followed for 20^s or 30^s by a roar or rustling sound which died gradually away. Professor Abbe explains (in the manner theoretically investigated by Eotvos, Poggendorff's 'Annals,' 1874, clii., p. 513) that the sudden clap of a meteoric detonation is probably not caused by the final disruption, but by the combined impulse of all the sound-waves reaching an observer's station from the long tract of the meteor's roaring passage through the air which is nearest to him, and from which all the sound reaches him almost simultaneously, while a prolonged roll, like echoes of the first sound, is afterwards heard from more distant portions of the meteor's track.

Accounts at Centreville and other places in Fairfax County, 30 or 40 miles W. a little S. from Washington, that the final explosion there was nearly overhead, approximately fix the meteor's end-point, which must, if not more distant from Washington, have been at the low height of not more than two or three miles above the earth to satisfy the observed altitude at Washington of its final disappearance. It seems more probable, as Professor Chickering has endeavoured to show from more distant observations, that the meteor's flight was continued considerably beyond Fairfax County, and that its final height (estimated at 20 miles by Professor Chickering) was not less than 10 miles over a point some 60 or 70 miles from Washington. The height and position of the remainder of the course are somewhat variously defined by a great number of distant observations at Danbury, Conn. (250 miles N.E. from Washington), at Newark, Delaware, where its commencement was nearly overhead, at Westminster, Mercersburgh, Baltimore, and other towns in Maryland, and at Richmond and Appomatox Court House in Virginia. The slope of its path in the

[1] By a Committee consisting of Hon. Peter Parker, W. L. Nicholson, and Cleveland Abbe, 'Bulletin of the Philosophical Society of Washington,' vol. ii. p. 139; April 7, 1877. Excerpt of 22 pp., with a map by W. L. Nicholson; from the authors.

northern sky at the two last, southern stations, and observations in northern stations at a distance from its track, combined with the localities over which its course seems to have passed nearly vertically, determine approximately the initial height along this course, and the direction and slope of the real path by which the fireball approached the earth. This is regarded in the Report as descending from about alt. $25\frac{1}{2}°$, 30° N. from E. (as measured from the map of the American States, and of the meteor's projected path, appended to it), from a height of about 90 miles over the northern point of Delaware State, in Newcastle County, to the low point of disappearance which it reached near Fairfax County. The celestial position of the corresponding radiant-point is at 115°+38°.

The observation most at variance with this deduction is that at Richmond, where the apparent downward slope of the meteor's path at disappearance was but 11° from horizontal, corresponding to a much slighter real gradient of the meteor's path than $25\frac{1}{2}°$, and to a height of only 42 instead of 90 miles above Newcastle County at its first appearance. A fair compromise between this and the Washington and other observations of the early part of the meteor's course would be effected if its downward flight to the extinction point is regarded as having reached it from a slightly modified direction at alt. 16°, 18° N. from E. instead of alt. $25\frac{1}{2}°$, 30° N. from E.; and of this new provisional direction the corresponding celestial radiant-point is 116°+24°, instead of 115°+38°. A certain range denoted by the position 113°($\pm$3°),+32°($\pm$6°) may perhaps be indicated as the bounding limits within which a direction of the meteor's flight may be considered to satisfy fairly the majority of the observations. This is not so far distant from Mr. Denning's observed position of a 'Geminid' radiant-point on December 31, 1872 (D. 1872–76, 27; at 108°+36°), as to make it improbable that this grand detonating fireball was a surpassingly large member of an already well-recognised and established system of December shooting-stars.

1878, April 2, 7^h 53^m p.m. Detonating fireball, Blackheath, Birmingham, and Leicester.—The real path assigned to this meteor in last year's Report [1] admits of some small corrections by comparison with an additional observation of the meteor (described in the present fireball list) by Mr. Christie at Blackheath, which was last year communicated to the Committee by Major Tupman. No very material alteration of the real course is, however, so produced, as Mr. Christie's observation is in extremely close agreement with those of the observers at Birmingham and Leicester. The radiant-point is given by approximate intersections of the three recorded tracks only three degrees from its former place; but a rather later commencement was observed at Blackheath than at Birmingham and Leicester, and the time of flight, though not noted carefully at Blackheath, was thought to be about one or two seconds only, instead of five or six seconds for its slow passage at Birmingham. The point of first appearance is lowered by the new observation, and lies somewhat nearer to Leicester.[2] The length of path corresponding to

[1] These Reports, vol. for 1878, p. 303.

[2] An erratum, caused by typographical indistinctness in a map, was corrected on the first page of the last year's Volume of these Reports, by a slight removal of the meteor's calculated place of first appearance, and a mistaken alteration of the town's name to Buckingham. The town really intended was Rockingham, on the borders of Leicestershire and Northamptonshire, about 20 miles E.S.E. from Leicester, over which the point of first appearance was supposed to lie. The adopted place of

it is therefore shortened, but the average time of flight observed at Birmingham and Blackheath, being at the same time less than that observed at Birmingham alone, the calculated real velocity still remains about 12 or 15 miles per second, which very nearly agrees with the parabolic speed, about 13 miles per second, of a meteor from the actual radiant-point. The position of this point is at 177°+49°, and Heis' shower-apex, M_7 for April 1–15 is at 180°+49°, so close to the observed position that another example is afforded by this double observation, of a detonating fireball proceeding from a known centre of divergence of ordinary shooting-stars.

1878, August 11, 10^h 10^m p.m. (Indianapolis time); West Virginia and Pennsylvania, U.S.—Descriptions of this meteor at three points in the central part of the United States, collected by Professor Kirkwood, enabled him to deduce approximately its real course. At Bloomington, Ind., it shot northwards some 20° in the east with a track slightly declining downwards from alt. 10° at first appearance in the east. By a rough estimate the time of flight scarcely exceeded two seconds. At Titusville, Pa., in that direction, near the point of concourse of the three States of Pennsylvania, Virginia, and Ohio, the meteors shot northwards in the west, lighting up the country more strongly than the full moon, with a greenish light, bursting at last into one large, and two red fragments, and giving rise to a report like thunder heard at an interval after the fireball's disruption corresponding to a distance from Titusville of 25 miles. The meteor also moved from south to north over Oil city, Venango County, Pa., a meridian through the western boundary of which county must have been the projected direction of its course upon a map. This real course is 348 miles east from Bloomington, so that the meteor's probable elevation at first appearance was about 77 miles over the northern part of West Virginia, and 160 or 175 miles from the place of final disruption of the fireball into fragments west of Titusville. The duration there of its illumination was 'momentary,' so that the only recorded estimates of its time of flight seem to denote a real velocity much greater than would correspond to original motion of the fireball in a parabolic orbit. The radiant point of the adopted real path is about at 292°–31°; but if (as is quite possible) the real path's geographical projection was considerably inclined to the meridian, its radiant was then at some point of a great circle of the heavens passing through this adopted place and through a point on the equator at about R.A. 10°.

1878, November 18, 9^h 50^m p.m.—Besides the determination of this small fireball's real course (seen by Mr. Corder and Mr. Denning at Writtle and at Bristol) by Professor Herschel, in the 'Observatory,'[1] where the original observations of its appearance are given as described in the accompanying fireball list by Mr. Denning, the real height and position of its course were independently calculated by Major Tupman with results which were not at very great variance with those already published. The height, position, and extent of the fireball's real path have now been reinvestigated by Major Tupman and Professor Herschel on the assumption that the short arc which it appeared at Bristol to describe, was but the end-part of a much longer flight, the whole visible extent of which was equally well seen and mapped at Writtle by

origin of the meteor's course is now 15 miles west from Rockingham, and nearer Coventry, over a point about 10 miles due south from Leicester.

[1] Vol. ii. (1878–79), p. 306.

Mr. Corder. No observation of the time of flight was recorded from which the real velocity might have been determined; but the real direction of the meteor's course is found to be so exactly conformable to a centre of divergence of a meteor shower detected by Mr. Denning on the nights of December 1–2, 1877 (including a bright fireball from 334°–11° to 322°–18½°), that a connection of the fireball with this newly discovered November-December meteor system may be pretty certainly concluded.

1877, December 9, $8^h\ 12^m$ p.m. Meteor as bright as Jupiter observed in Kent and Essex, and at the Royal Observatory, Greenwich.—The path of this bright meteor has been computed from the data of its appearance at Writtle and Bromley given in last year's report, with the addition to them of observations of the meteor in London, and at the Royal Observatory, Greenwich, now added in the present fireball list. Mr. Corder's opinion that the meteor belonged to a system of bright streak-leaving, long-pathed meteors diverging on the same night from the direction of a companion radiant of the 'Geminid' shower, near ι Geminorum, is exactly confirmed by the combined projection of all the observations; and a satisfactory agreement is at the same time found among them for determining the height and locality, and the real velocity of the meteor's flight. These results Major Tupman has deduced with the new materials of the Greenwich and London observations which he supplied, among other reductions of double observations of large meteors which he obtained last year, and he obligingly communicated them to the Committee as they are briefly represented in the present Table.

1878, December 30, $6^h\ 55^m$ p.m. (Indianapolis Time); Ohio, Indiana, and Pennsylvania, U.S.—This is another bright fireball of which Professor Kirkwood has collected and discussed some observations (see the accompanying general meteor list, and the fireball of August 11, 1878, above), in the Paper on Large Fireballs of the years 1878–79, which he communicated in May last to the American Philosophical Society. By a description at Washington, Pa., the attention of an observer walking eastwards was arrested by a sudden light like that of an additional street lamp lighted close behind him. Turning after a little time to that direction, he saw a meteor about half the full moon's apparent diameter (which was then shining brightly, but behind houses) falling in the W.N.W., large and brilliant, and of a slight greenish colour. After coursing about 24° (from near α Cygni to near α Lyræ, by a later visit with Professor M'Adam, of Washington and Jefferson College, to the same place) it changed its colour to a reddish tint and disappeared. It was seen at Anderson, Indiana, about 270 miles due west from Washington, Pa., commencing due east, at an altitude of between 15° and 17°, and immediately disappearing behind houses.

The description at Wooster, Ohio (which is given in the accompanying meteor-list) assigned very exact positions of both the points of appearance and disappearance of the course. Combined with the account at Washington, Pa., it gives the end-height and position of the meteor over a point (in Tuscarawas County, Ohio) 70 miles distant W. by N. from the latter station, while the point of commencement is found, by combining the account at Anderson, Ind., with that at Wooster, Ohio, to have been 72 miles over Columbiana County, Ohio, lat. 40° 50′ N., long. 3° 40′ W. from Washington. The whole length of the track seen at Washington, Pa., was about 85 miles, descending with a slope of 45° from

a direction nearly due N.E. towards S.W. This corresponds at the time and place of the meteor's disappearance to a celestial position of the radiant point at 174°+56°, near γ Ursæ Majoris. Of its real speed of motion exact enough observations of the fireball's time of flight were not obtained to afford a satisfactory determination. From the nearest point of view at Wooster, Ohio, a disruption of the nucleus was seen about 20° along its course before its point of disappearance, of which no mention is made in the account at Washington (much further from the real track), so that the fragments into which the meteor then broke appear to have been unseen (as was also the case in distant observations of the large fireball of August 11, 1878) at the more distant station. The final height determined is that of the disruption seen at Wooster, and it seems probable that the fragments pursued their course and penetrated while in sight to a still closer proximity than that deduced above of 17 or 18 miles, to the surface of the earth.

1879, January 12, $7^h\ 25^m$ and $7^h\ 32^m$ p.m., Berlin time; large fireballs, the first detonating, seen in Bohemia and Saxony.—Of these two fireballs, which appeared within a few minutes of each other, Professor von Niessl collected a large number of accounts sufficiently exact and definite in their descriptions, in spite of cloudy skies on the date of their appearance, to enable him to assign their real courses with precision.[1] The two meteors pursued real courses over the middle of Bohemia, nearly at right angles to each other, the first extremely large and detonating, the second a much smaller meteor, but also casting a strong light. It was hence simply observed in some of the locally described accounts that the particulars furnished by various observers were too contradictory and opposed to each other to be worth recording in detail; the detonation of the first meteor seems also to have been sometimes ascribed to the second one, with whose appearance, at some places, it must have occurred almost simultaneously. But both meteors were well seen and described by at least one single observer (the railway station-master at Neucunnersdorf), and exact descriptions, at other places, of the two meteors present no confusion, and could in general be easily distinguished and separated from each other.

The nucleus of the first meteor, as seen from a distance, was globular, resembling the moon's disc in apparent size (and perhaps also in colour, which was not noted), followed by a thin tail, and bursting at last into sparks, while a portion pursued its career and was visible for a short distance further. It cast a light as strong as that of a moonlight night over the greater part of Bohemia, and as bright as daylight in the streets of Prague. The sound of its explosion in that city was like a sudden thunderclap, of 3-20 seconds duration, heard in a minute and a half after the meteor's disappearance, shaking doors and windows, and rattling together objects placed on shelves and tables, and even according to one description at Rostock, near Prague, breaking window-panes. The time-interval of the sound probably corresponds to a distance (about 18 miles) of the nearest point of the meteor's track from Prague, rather than to that (about 27 miles) of its end-point from the town.

The fireball ended its course at a height of only 9 miles, nearly over Rakonitz, due west of Prague, where it seems to have arrived by a flight of somewhat uncertainly determined length from the direction of a

[1] *Sitzungsberichte* of the Imperial Academy of Sciences of Vienna, vol. 79, May 8, 1879. Excerpt of 22 pages, from the author.

radiant-point whose celestial position was at 133°+19°, and whose apparent place for the horizon of Rakonitz at the time of the meteor's apparition was about E.N.E. alt. 14°.[1] Mr. Denning's January shower of 'Cancrids' (December 21–January 5, 130°+20°), and the comet of 1680 (December 26, 132°+21·5°),[2] together with the fireball of January 19, 1877, seen in England, Wales, and Ireland,[3] all present radiant-points with which this new detonating fireball's real point of departure was thus found to be nearly concentric in position.

Although doubtless visible (as some of the descriptions show) at a much earlier period of its flight, the first point at which the fireball's course was well observed, and for which the time of flight was also noted, was at a height of 41 miles above the earth's surface, 125 miles from the end-point of its track. This distance it traversed in 5 seconds; and shorter lengths of the latter part of its flight were seen to be traversed, by five other observers, in times varying from $2\frac{1}{2}$ to 5 seconds. The meteor's mean velocity at last, from all these estimates, was 17 miles per second; while that of the fireball of January 19, 1877 (scarcely so well determined) was not less than 35 miles per second. The parabolic speed of meteors from this radiant-point is 23 miles per second, which is intermediate between these two observed velocities.

The near approach of this fireball's luminous track to the earth's surface is a rare and remarkable feature of the above described results of its appearance, and it is very certainly determined. The depth to which the igneous mass of the meteor penetrated the atmosphere accounts at once, as Professor von Niessl conjectures, for the violence of the explosion, and for the moderate velocity with which it appears at last to have been traversing the air. The same condition of unusually deep penetration he considers may also have occasioned the remarkably slow relative velocity of the fireball of November 27, 1877, whose end-height Major Tupman found to be only 14 miles, and whose velocity relative to the earth he showed not to have exceeded 5 miles per second, answering in the visible part of that fireball's flight to a very short elliptic, and nearly circular orbit round the sun.

It may be noticed here that a remarkable resemblance of the latter fireball's real orbit to that of Biela's comet was pointed out by Mr. Hind, of which the following particulars, here transcribed in full, appeared in 'Nature,' vol. xix. p. 484, March 27, 1879.

'Captain Tupman thinks the radiant-point was pretty accurately determined in R.A. 285°, Decl.+64°, or in longitude 340°, and latitude +83°. The elements of the real orbit which, with the aid of the other corresponding data depending upon the earth's position in her

[1] With the omission of one discordant estimate, at Prague, of the meteor's apparent slope of path, a better defined position of the radiant-point, at 132°+21°, would be obtained, Professor von Niessl shows, presenting an even closer agreement than the adopted place with the above-quoted radiant-points.

[2] See a note of this accordance of the comet with Denning's meteor shower in these Reports, vol. for 1877, p. 167.

[3] These Reports, vol. for 1877, pp. 118, 153; and vol. for 1878, p. 267 (where the shower D8, 1877, is erroneously indicated as the 'Cancrid' system, with which the fireball's radiant-point appears to have been concentric). Professor von Niessl has also re-computed the real path of the fireball of January 19, 1877, from its descriptions; and has obtained a position of its radiant-point at 135°·5+22°, instead of at 135°+27° (±6°), the place assigned to it in the *Monthly Notices of the Royal Astronomical Society*, vol. xxxviii. p. 228, and xxxix. p. 281, and in the place here quoted, where its real path was first investigated, in these Reports.

orbit are thence deduced, are as follows, taking the real duration as fifteen seconds. (The elements of the orbit of Biela's comet at its last appearance in 1852 are added in a contiguous column for comparison.)

	Fireball of Nov. 27, 1877.	Biela's comet (orbit in 1852).
Perihelion distance	0·9858	0·8606
Longitude of perihelion	70° 6′	109° 8′
„ of ascending node	245 50	245 52
Semiaxis major	1·1691	
Eccentricity	0·1568	0·75625
Inclination	15° 0′	12° 33′
Anomaly	−4 16	
Periodic time	462 days	
Motion	direct	direct

'The precise Greenwich time of the occurrence of the meteor was $10^h\ 26^m$.

'If the duration of visibility is diminished to $7\frac{1}{2}$ seconds, the elements are still very similar to the above, the semiaxis major becomes 1·3785, and the period 591 days. Captain Tupman remarking that such favourable conditions for inferring the orbit of a meteor very rarely happen, adds, it is sufficient for the establishment of a short periodic time (such as 500 days) that "the meteor moved slowly from a fairly well-determined radiant distant about 90° from the point of the heavens towards which the earth's motion was directed."

'We may mention that there is one singular circumstance not alluded to in Captain Tupman's note: the elements defining the position of the orbit of the meteor have a striking general resemblance to those of the orbit of Biela's comet, in the descending node of which body the earth was precisely situated at the time.'

With sufficient allowances for possible perturbations and retardations of its course by earlier encounters with the earth, it seems extremely probable that the calculated real orbit of this remarkable and unusual fireball may not be irreconcilable with its original derivation from the Biela meteor stream.

The observations of the second fireball of January 12 last, in Bohemia, all described a meteor moving nearly from S. to N., with a large disc of bluish-white light casting a strong illumination like that of moonlight on all objects. Exact particulars of its direction were obtained from eight stations near Salzburg, in the south, to Zittau, on the Bohemian frontier of Saxony in the north, showing that its real path instead of crossing the middle of Bohemia, as that of the first did, almost horizontally from east to west, traversed the western part of Bohemia with a rather steeper descent from south to north, crossing the northern frontier of the country at last into Saxony. It terminated here at a probable height of about 23 miles over Grossenhain, a point at a little distance N.N.W. from Dresden, where it arrived by a flight of 130 miles, descending from alt. 28°, 9° E. from S. at a height of about 78 miles over the neighbourhood of Pibram in the south-western part of Bohemia. At a height of about 40 miles, near its passage across the Saxon and Bohemian frontier, the nucleus divided or was partly extinguished at its maximum, a much smaller luminous body only pursuing the same course farther to the point of disappearance. No sound of this explosion or of any other disruptions along its course appear to have reached observers who were most favourably situated by their closeness to the lowest and most brilliant portions of its flight for

hearing them; but several notes of rumbling sounds heard simultaneously with the meteor's passage appear to be referable to the distant detonation of the earlier meteor. The real velocity, as far as it can be gathered, from only two observed durations of limited portions of the track near its termination was (from each of these) about $12\frac{1}{2}$ miles per second. This is exactly the parabolic speed of meteors from the same radiant-point, the celestial position of which, as obtained from the foregoing discussion of the meteor's real course, was at $52°-10°$ ($\pm 5°$).

Professor von Niessl points out the coincidence of the resulting radiant with that of the fireball of January 7, 1877, observed at Birmingham and in London, of which he finds the radiant-point from the observations to have been about $48°-11°$, instead of the place assigned to it by similar projections in these Reports (vol. for 1877, p. 135), at about $58°(\pm 8°)-14°$. But the position of both of these fireballs appears yet to be in very close agreement with the centre of the January 'Eridanid' shower which Mr. Denning found on January 4–20, 1877 (D. 2, 1877) to be situated very close to γ Eridani, at $57°-12°$.

1879, January 28, $2^h\ 28^m$ a.m. (local time); Michigan and Wisconsin, U.S. A detonating fireball.—Local newspapers in these States teemed with eloquent descriptions of the fiery scene and crashing explosion which attended this fireball's appearance in the middle of the night. But among them Professor Kirkwood was able to collect only a few accurate and detailed descriptions of its apparent course. A night watchman in Traverse City, Michigan, furnished Mr. T. Bates, the editor of the 'Herald' of that city, with the following statement:—

'Was on watch, passing from due west to east; saw a great light; turned quickly, and saw a ball of fire over my right shoulder; turned to left and watched it until it disappeared; when first seen it appeared about as high as ordinary rain-clouds; appeared to me larger than full moon; full moon looks to me to be 18 or 20 inches in diameter; meteor appeared to pass me, and move out of sight at about the rate of speed a descending rocket has after its explosion; had a good chance to see it plainly; just after passing me a singular thing occurred; a ring of fire seemed to peel off the meteor itself, and this followed the ball of fire out of sight, but dropped a little behind it; it was perfectly distinct, and appeared to be hollow, for I could see a dark centre. Everything was as light as day. I looked at my watch as it disappeared; it was just 28 minutes after 2 o'clock. I passed on my beat, and shortly the terrific explosion came. It shook and jarred everything around. I immediately looked at my watch, and it was 32 minutes after 2.'

Seeing it, when facing east, appear over his right shoulder at no extreme altitude, and pass before him to his left-hand side, this observer must have watched the fireball travel before and east of him at some considerable altitude on a course directed nearly from S.W. to N.E. At Charlevoix, Michigan, about 35 miles N.E. by E. from Traverse City, the fireball, in fact, burst overhead. It appeared four times as large as the full moon, with an intensity of brightness surpassing that of sunshine, and its explosion, which followed at a very brief interval, resembled that of musketry. Its direction was nearly from S.W. to N.E. About as much further in the same direction, at Cheboygan, Michigan, the light was seen within doors, casting shadows as it approached from S.W. until it disappeared. Its greatest (and apparently first) altitude (?), estimated by the positions of the shadows, was found to be about 45°. No sound of

an explosion was audible at this place (near, but in advance of the meteor's termination), which seems to be confirmatory of the view, elsewhere expounded, that the sudden concussion of a meteor-clap is not the consequence of a disruption, but a cumulative sound, or combined acoustic effect, at places near to and on one side of the meteor's course, of the sound produced, and reaching an observer simultaneously from long tracts of its fiery passage through the air.[1] Regarding the meteor's course (apparently, from Mr. Walton's description, indoors, of the moving light and shadows, at Cheboygan) as a steeply descending one, Professor Kirkwood is led, roughly, to the following general conclusions:—The fireball first came in sight nearly 100 miles over a point about 30 miles S.W. of Great Traverse City (at lat. 44° 25′, long. 9° W.), and it disappeared about 26 miles above a point about 42 miles N.E. by eastwards from that town. The whole visible track was 124 miles, and its projection on the earth's surface 66 miles in length from a direction S.W. by S. towards N.E. by N. Of the time of flight, which was described as several seconds, and of the real velocity, except that the observations indicate a rather slow motion, nothing very definite can be affirmed.

The altitude of the radiant-point appears from this description to have been about 55°, and from the course, $33\frac{1}{2}$° W. of S., from which it was directed, the meteor's radiant-point may be assigned provisionally at about 142° + 14°; but this cannot evidently be regarded as an exact determination. It is close to the border-line dividing Leo from the constellation Cancer, and a suspicion may perhaps be entertained that, like the fireballs above described, of January 12, 1879, and January 19, 1877, this imposing aërolitic meteor of January 27–8, 1879, may have been a conspicuous member of one of the 'Cancrid' meteor systems which have been recognised as discernible in December, January, and February, and as apparently concentric in the first and last of those months with the hypothetical radiant-points of the comets of 1680 and 1833.

1879, February 22, $12^h\ 20^m$ a.m. Detonating meteor; Essex.—According to the descriptions at Haverhill and Saffron Walden, two towns scarcely ten miles apart east and west of each other, on the northern confines of Essex, that the meteor passed from south to north between them with a prodigious light and a report like thunder, audible in 20–45 seconds, going east of the zenith to an end-point in N.E. at Saffron Walden, and going overhead and down to N.W. at Haverhill, as the height above these towns corresponding to the sound interval is only six or eight miles, the meteor's track, at its close near them, cannot have extended many miles northward of their position into Cambridgeshire. A height of five or six miles nearly vertically over Newmarket, about eight or ten miles north of Haverhill, must be the utmost height and distance northward from that town at which the final disappearance of the fireball can be supposed to have occurred, if the time interval at the former place and at Saffron

[1] The example of the detonating fireball of April 2, 1878, seems to be a parallel one to the case of the present meteor. The sound of its extinction and nearest approach to the earth, about 25 miles from Birmingham, towards which town its course was nearly directed, was not perceived there, although at the greater distance (about 30–35 miles) at which the meteor passed, when nearest, by the town of Leicester, a sound like thunder, attributed to the meteor, was heard at that place by Mr. F. T. Mott. The observer at Galashiels on May 12, 1878, also heard a peal of thunder, apparently proceeding from the fireball of that date, no sound of which was heard in Edinburgh or Bathgate, nearly over which towns the meteor disappeared. See the last volume of these Reports, for 1878, pp. 305, 306.

Walden can be regarded as carefully observed.[1] But the statement at Bury St. Edmonds, 15 miles due east of Newmarket, that the meteor 'was seen in the west moving slowly downwards like a ball of fire falling to the earth,' while it cannot be strictly interpreted as a vertical descent, since the meteor reached that neighbourhood from vertically over Brentwood, in *the south*, yet points to Newmarket, 15 miles due west of Bury, as about the extreme point which the meteor perhaps reached, northwards, in its descending route. It 'passed overhead' at Brentwood, 'from S.S.W. to N.N.E.,' a place of observation which is about 40 miles *due south* from Newmarket, and 20 miles E.N.E. from London; and at Godalming, 30 miles S.W. from London, it lighted the interior of a room facing south so strongly, that a real path of the meteor towards Newmarket passing nearly over or but little east of London, and descending with a sensible inclination, appears necessary to satisfy these several observations, and it accounts perfectly for the description given of its course at Bury, that it appeared 'descending slowly like a fireball falling to the earth.' The line of flight in this course probably extended from about 75 miles over the neighbourhood of Redhill to five miles over a point two or three miles south or east from Newmarket, passing over Greenwich, and at a height of 40 miles over a point 10 miles west from Brentwood. Its slope is from alt. 45°, 20° W. from south; and its length (for which no exact limits can be stated) was about 110 miles. It yet seems possible that the Bury and Brentwood observations may be satisfied by a rather lower line of flight than this, if the disappearance was only five or six miles high five or six miles north of Haverhill, which is not at all impossible. With such small admissible adjustments of the end-point, a great variety of initial points and of slopes and directions of the real course might be selected which would not at all conflict with the exceedingly distinct but yet not accurate and precise descriptions of the apparent track at Bury and at Brentwood. Heights of 50–75 miles at commencement over any point between Godstone or Reigate and Dorking or Guildford in Surrey, combined with a proper end-point, would thus answer the imposed conditions, presenting various slopes of path from altitudes of 35°–45°, and from directions between 15° and 30° W. of south. These paths pass at heights of 30 to 40 miles over points not more than 10–15 miles west from Brentwood, and might all there be perfectly described as passing 'overhead.' They would all occupy the south-western sky at Bury, ending due west, or but little south of west, and might there be described as 'in the west;' and lastly, their apparent slope in the sky, towards disappearance, would never be less than 45° or 50°, so as to admit fairly of the description there, that the meteor appeared 'falling towards the earth.' That the meteor's slope of path was much greater than 45° appears scarcely probable, as the long extent and duration of the full splendour of its flight, generally attested by the observations, would not be very easily accounted for by a real path whose slope was much greater than this, or whose grade at the utmost materially exceeded 50°. The limits above adopted as extreme possible positions of the radiant-point were at the time of the meteor's appearance between the head of Hydra and Sextans at R.A. 135° to 145°, and N. decl. 0° to 10°, immediately adjoining the equator, between those constellations,

[1] The interval noted by a policeman at Saffron Walden was '20 seconds, or the same as the duration of the meteor's light.' At Haverhill, an observer states, 'I should think that the meteor lasted five seconds or more; and half a minute or three quarters of a minute after there was a sound like thunder.'

on its northern side. There appears to be a long-stationary radiant near this place, Greg, 1876, No. 15, January 1–March 16, 141°–2°, which includes Mr. Greg's earlier radiant centres, S_1 SG_1, and some more recent determinations. Thus in Tupman's catalogue, No. 3, January 4, is at 142°+5°; and the radiant-point of the fireball of March 17, 1877, which he derived from the observations (these Reports, vol. for 1877, p. 135), was fairly well determined at 145°–5°. In Mr. Denning's new list of stationary meteors, one of fourth magnitude, observed by Mr. E. F. Sawyer on February 24, 1878, is recorded at 145°+8°, which is very close to the presumed place of the radiant-point of the great detonating meteor seen this year on the morning of February 22.

1879, February 24, 2^h 53^m a.m.; Yorkshire. Large detonating fireball.—The surprising and alarming nature of this meteor's apparition in York and its neighbourhood was described in the 'York Herald' and in the 'Middlesborough Gazette.' A pear-shaped ball of fire travelled at York across the sky, casting a light upon the town as strong as that of day. After a moment's interval following the fireball's disappearance, a peal of thunder burst upon the town, wakening sleepers who had not yet been aroused by the blaze of light, and shaking doors, windows, and the houses. The same occurred at Stockton, but a snowstorm, which only began immediately after the sight appeared at York, was there raging, and also at Newcastle at the time; and the intensity of the light at these places, 'as bright as a summer day,' which the invisible body shed upon the scene, 'changing in about a dozen seconds from white to a beautiful blue before it disappeared,' was all the more surprising (though perhaps exalted by the whiteness of the snow) from the thickness of the storm. The shock of the explosion was even more incomprehensible on this account at Stockton than at York, and it seems to have more universally inspired alarm, and to have passed for an earthquake shock, in the northern part of the county than at York, where the fireball was well seen. At Liverpool the sky was clear, and the meteor, like a powerful rocket, but without a tail of sparks, illuminated the town vividly, and was watched for some seconds, even in streets from which little of the sky was visible, travelling rapidly away in a south-easterly direction. It was distinctly seen at Stockport, near Manchester, an observer walking N.N.E. perceiving, when half dazzled by the light, up in the air on his right, a whitish globe of light with a mist of pale colour round it that lighted up the landscape for a second and made every object visible in the distance. At Birmingham, officials leaving the chief post-office turned about at the light, which was like that of an electric lamp, and called each other's attention to a large pear-shaped object falling slowly down over the houses in a E.N.E. or N. by E. direction, leaving a bright tail of some considerable length behind it, and soon disappearing, when the sky then became intensely black. The harbour-master of Shoreham (six miles west of Brighton, and 213 miles south from York) saw it pass in about 30 seconds between two hills north of him, beginning at an altitude of 11° 'N. by W.,' and going thence 'to N.W. by W., in a considerable curve,' with a long tail like a kite, of a magenta colour, making everything around as bright as day. At Dundee (185 miles N.N.W. from York), it 'fell in a westerly direction from a dark cloud hanging apparently over the rising ground west of Newport. When first seen it gave forth a clear silvery light, which quickly changed into purple, and afterwards the meteor assumed a bar-like form, one end of which was brightly red. The morning was clear and

frosty, but notwithstanding this the temporary illumination was almost startling in its brilliancy.' ('Dundee Advertiser,' March 25, 1879.)

The vague descriptions contained in nearly all the newspaper paragraphs not allowing of any accurate deductions, Mr. J. E. Clark, of York, applied himself, by correspondence with persons at a distance, and by many actual measurements at York, to collect materials for determining the meteor's real path. At York the meteor disappeared, as well as could be ascertained, 41° W. of S., altitude 10°, observed by a point above the Minster roof, near one of its towers. The point of first appearance was less certain, but whether to the north or to the south side of the zenith, the apparent path of the meteor certainly passed very nearly overhead. The time interval of arrival of the sound was practically obtained in several cases by repeating actions during the interval from recollection, and it was very nearly $1\frac{1}{4}$–$1\frac{3}{4}$ minute, while one observer estimated it at half a minute, and another as 'fully two or three minutes,' or twice the longest time taken for a clap of thunder to arrive. The former of these exceptional cases is probably below, and the latter, though confidently stated, probably above the truth, and a lapse of one and a half or two minutes, it seems probable, must have really intervened, corresponding to a distance or real height of the meteor's flight over York, of 18–25 miles. For determining the height and position of the point of disappearance but one useful observation, that of Mr. S. Walliker, at Hull, can be satisfactorily combined with the York line of sight, although the very distant description at Dundee confirms in a general way the position which was so obtained. By a careful plan of his position, which was at his own front door, Mr. Walliker found the apparent path at Hull to have been from 4° W. of N., alt. (estimated) 60°, beginning perhaps before caught sight of about 10° E. of N., to W. by N., alt. 20° (estimated altitude). The intersection of the latter line with that of the disappearance seen at York is midway between Selby and Leeds, only 16 miles S.W. from York. The corresponding height of the meteor above the earth's surface at this point, on the York line of sight, is only three miles; another observer's estimated altitude of 30° would give ten miles, but with allowance for unconscious exaggeration near the horizon, cannot increase the final height certainly to more than six or seven!

To find the point of first appearance, from equally scanty data, a valuable account at Whitby, by Captain E. Heselton, of the 'Margery,' passing two miles N.W. of Whitby on the voyage from Seaham to Scarborough, when the meteor was observed, states that it passed directly overhead, from alt. 45°, 20° E. of N. to alt. 45°, 20° W. of S., a course which, prolonged, passes through York and Selby, and substantiates the other observations. On this track the direction and distant altitude at Hull, as well as those obtained at York, make the meteor's height over Whitby 65 or 80 miles; but regarding them, from their character as estimates, as overrated, the probable height of the fireball over Whitby, 40 miles N.N.W. from York, can scarcely have been more than 40 or 50 miles. This estimate, making the meteor's height as it does, over York, about 17 or 18 miles, agrees with the time interval of the sound there, and leads it to be regarded as probably a near approximation to a point of early appearance in the meteor's real path. That it began at a much earlier point is shown by Captain Heselton's first view of it 45° before reaching the zenith at Whitby, and by the brightness of its light behind

[*Continued at page* 120.]

A LIST OF LARGE METEORS OCCASIONALLY

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration	Position or Apparent Path From α δ	to α δ
1862 Nov.27	h m [Probably 5 47 p.m. See Rep. 1863, p. 324.] No time stated.	Colchester, Essex.	. . . .	. . .	Rather slow motion.	. . . .	
1876 Sept. 1	9 48 p.m.	Tedstone Delamere, near Worcester.	As bright as Venus.	. . .	. . .	From due S., alt. 23°, to S., 8° W., alt. 17° (altitudes measured; azimuths, by known bearings, 'true').	
1877 Nov.19	8 30 p.m.	Scarborough, Yorkshire.	Twice as bright as Venus.	White, then red.	4 seconds; moved slowly.	Travelled in a S.E. direction, and disappeared behind hills.	
Dec.29	6 2 p.m.	Blackheath, near London.	As bright as Jupiter, and less bright than Venus.	. . .	0·3 seconds	Passed just above α Andromedæ, ⅔ of the way to η Pegasi.	
1878 Jan.31	11 20 p.m.	Ibid. .	Brighter than Venus.	Bluish white.	2¼ seconds; very swift.	From 167° + 10° to 110° − 10°.	
Mar. 9	(6 42 p.m. Washington, M.T.)	Boston, U.S.A.	Much more brilliant than Mars.	. . .	About 3 seconds.	Commenced at 48° + 27°.	
April 2	7 54 p.m.	Blackheath, near London.	Thrice as bright as Venus.	. . .	Between 1 and 2 seconds; not exactly noted.	From near δ Cassiopeiæ to 11° + 32° (5° s.p. β Andromedæ).	
24	8 12 p.m.	Wimbledon	Large disc, 5′ × 3′; its light not intense, but total brightness > ♀.	Yellowish	. . . .	First seen about 2° N. of Procyon; disappeared about 57° W. of S., alt. 22°.	
June 3	(2 59 a.m.)	Chicago, U.S.A.	As bright as the moon when four days old.	. . .	. . .	From near the zenith to about 4° above β Cassiopeiæ.	
July 1	10 45 p.m.	½ mile E. of the Royal Observatory, Greenwich.	Very brilliant	White .	. . . .	Began due E., alt. 45°; lost behind trees 39° W. of N., alt. 3½°.	
July 28	(9 7 p.m.)	Boston, U.S.A.	As bright as Mars; a fireball.	Deep red	3 seconds.	From 332° + 56° to 6° + 51°.	

OBSERVED, CHIEFLY IN THE YEARS 1878–1879.

Length of Path	Direction or Radiant-point	Appearance, Remarks, &c.	Observer or Reference
. . .	. . . . .	Burst like a firework, with a dull report; but no other fireworks were seen.	F. Rutley.
. . .	. . . . .	. . . . .	F. S. Lea. (Communicated by G. L. Tupman.)
. . .	. . . . .	. . . . .	G. E. Mass. Do.
. . .	. . . . .	A diagram gives the apparent path from 5° + 31° to 347° + 28°.	W. H. M. Christie. Do.
. . .	Course rather concave to the horizon.	A diagram gives the apparent path from 171° + 11° to 110° − 12°.	Id. Do.
About 15°	Directed towards S.S.W.	Did not explode or break; left a beautiful train, much the colour of Mars.	Berlin H. Wright. Boston 'Science Observer,' vol. i. p. 60.
. . .	. . . . .	After a sort of explosion, the nucleus, becoming suddenly faint and nebulous (perhaps behind floating clouds), proceeded nearly 5° further; left no distinct streak. [Seen also at Birmingham and Leicester. See Report for 1878, p. 292.]	W. H M. Christie. (Communicated by G. L. Tupman.) [For a calculation of the real path, see Appendix I.]
10° or 15°	Descending a little northwards at a very steep angle.	Nucleus pear-shaped; left behind it, after travelling about 10°, three or four very bright blue stars, and then vanished in clear sky. No sound heard, though waited for 3 minutes.	F. C. Penrose. 'The Times.'
. . .	. . . . .	Burst into seven or eight fragments near α Cassiopeiæ.	E Colbert. (D. Kirkwood, 'Am. Phil. Soc. Proceedings,' May 2, 1879.)
. . .	. . . . .	Left no streak. Azimuths (true) and altitudes determined by G. L. Tupman.	Rev. Lloyd Jones. (Communicated by G. L. Tupman.)
1° . .	. . . . .	Left a red streak . . .	E. F. Sawyer. 'Am. Jour. of Sc.,' Nov., 1878.

A LIST OF LARGE METEORS OCCASIONALLY

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration	Position or Apparent Path From α δ to α δ
	h m					
July30	11 52 p.m.	Brighton .	A bright meteor .	Bluish white.	1 second; very swift.	From ½ (βγ) Andromedæ to (δ ε) Piscium path carefully noted.
Aug.11	3 31 a.m.	Sunderland .	As bright as Venus.	Yellow .	Very quick .	Passed ½° left of Aquilæ, 1° or 2° before its disappearance.
11	(10 10 p.m. Indianapolis time)	Bloomington, Ind., U.S.A.	About ⅓ of the moon's diameter	. . .	Not more than 2 seconds; very rapid.	Began due E., or E. 2° or 3° S. alt. 10°, and shot northward to 20° N. of E. very near the horizon.
7	10 27 p.m.	Debenham, Norfolk.	As bright as Jupiter.	. . .	. . .	12+60 to 10+45
7	10 29 p.m.	Ibid. .	Twice as bright as Jupiter.	. . .	. . .	335+26 to 335+12
7	About 10 30 p.m.	Ibid. .	As bright as Jupiter.	. . .	. . .	320½− 5 to 328¾− 1
16	About 7 15 p.m.	Holdsworthy, Devon.	Two bright meteors.	. . .	Moved with great speed	Disappeared behind storm clouds, near the horizon.
20	8 57 p.m.	Between Yarmouth and Lowestoft.	As bright as Jupiter.	. . .	. . .	279−4½ to 275−2¼
21	1h a.m.	Debenham, Norfolk.	Bright meteor .	. . .	. . .	Began due S., alt 45°.
22	(10 2 p.m.)	Boston, U.S.A.	Fireball as bright as Mars.	Deep orange .	3 seconds .	248 +63 to 230 +77
27	9 32 p.m.	Debenham, Norfolk	A fine meteor .	. . .	. . .	339 +18 to 338½+14
31	11 0 p.m.	Ibid. .	⅓ diameter of the moon.	. . .	. . .	From a little W. of S. to S.E. by E., alt. about 26°.
Sept. 1	About 10 20 p.m.	Bristol .	Nearly as bright as Venus.	. . .	Very swift .	161 +70 to 155 +56
8	8 35 p.m.	Ibid. .	Brighter than Venus.	. . .	Very swift .	246 +21 to 244½+ 5
16	9 0 p.m.	Henryville, Clark Co. Ind., U.S.A.	About ⅕ or ¼ diam. of the moon.	. . .	. . .	Began near γ, and passed across δ Ursæ majoris.

OBSERVED, CHIEFLY IN THE YEARS 1878–1879—*continued.*

Length of Path	Direction or Radiant-point	Appearance, Remarks, &c.	Observer or Reference
. . .	. . . . .	No explosion; streak visible 2 seconds, broadened and disappeared. 3 or 4 seconds later a small meteor shot 2° or 3° in the same direction below ϵ Piscium.	H. Pratt. (Communicated by G. L. Tupman.)
Rather long course.	Directed from 2° left of δ Cygni.	Left a streak. A Perseïd. .	T. W. Backhouse.
20° or 25° .	At first nearly horizontal, at last sloping downwards considerably.	No final disruption of the nucleus seen, nor sound of an explosion heard. (Seen also at Titusville, Pa.; exploding with loud detonation in the west).	J. A. Bower. (D. Kirkwood, 'Am. Phil. Soc. Proceedings,' May 2, 1879.) [For real path of meteor see Appendix i.]
. . .	. . . . .	Left a streak	V. Cornish. 'The Observatory,' vol. ii. p. 205.
. . .	. . . . .	Appeared about two minutes after the last meteor.	Id. (Ibid.)
. . .	. . . . .	Seen by another observer about the same time as the last two meteors.	(Ibid.)
. . .	Towards S.W. . . .	One bright meteor following another at a little distance.	Mr. Bassett. 'The Observatory,' vol. ii. p. 203.
. .	. . . . .	. . . . .	Communicated by W. F. Denning. 'The Observatory,' vol. ii. p. 205.
5°. .	Shot westwards . . .	. . . . .	Ibid.
5° . .	. . . . .	Nucleus with orange-coloured train.	E. F. Sawyer. 'Am. Jour. of Sc.,' Nov. 1878.
. . .	. . . . .	. . . . .	Communicated by W. F. Denning. 'The Observatory,' vol. ii. p. 205.
.	. . . . .	Lit up the landscape. Followed at 11^h 20^m by a smaller meteor, taking the same direction.	Id.; Ibid.; (and p. 243, foot of the page.)
.	Radiant of this and the next meteor at 295 + 83.	Left a short streak at 156° + 58° for 10 seconds.	W. F. Denning.
.	. . . . .	Left a streak of 4° for 25 seconds. Resembled the last meteor very closely.	Id.
.	. . . . .	. . . . .	Benj. Vail, D. Kirkwood, 'Am. Phil. Soc. Proceedings,' May 2, 1879.

A LIST OF LARGE METEORS OCCASIONALLY

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration	Position or Apparent Path From α δ to α δ
1878. Sep. 21 (?)	h m 9 3 p.m.	Newcastle-on-Tyne.	About $\frac{1}{5}$ diam. of the moon.	. . .	. . .	From between η Ursæ majoris and Arcturus to 5° below γ Ursæ majoris.
22	(8 33 p.m.)	Boston, U.S.A.	Brighter than Jupiter.	Deep orange	2 secs.; very slow.	From $2\frac{1}{2}° - 17\frac{1}{2}°$ to $5° - 22°$.
27	3 5 a.m.	Bristol . .	As bright as Jupiter.	. . .	Very swift .	From $66° + 8°$ to $61\frac{1}{2}° - 3$.
30	(8 $43\frac{1}{2}$ p.m.)	Boston, U.S.A.	Nearly as bright as Jupiter.	Orange .	Rather slow speed.	From $29° + 42°$ to $41° + 36$.
Oct. 4	11 p.m.	Debenham, Norfolk.	As bright as Jupiter.	. . .	Not very rapid.	From $353\frac{3}{4}° + 2°$ to $4\frac{1}{2} + 12\frac{1}{2}°$.
7	9 15 p.m.	Ibid. . .	Very fine meteor .	. . .	. . .	From $338° - 3°$ to $13° - 6\frac{1}{2}°$.
8	7 49 p.m.	Sunderland .	As bright as Jupiter or Venus.	Deep yellow, but variable in colour.	4 or 5 secs.; very slow.	Disappeared at $108° + 45\frac{1}{2}$.
8	10 10 p.m.	Leicester . .	As bright as Venus	Bluish white	2 secs.; very swift.	From $\frac{1}{2}°$ E. of α, passed over γ and β to 4° or 5° W. of β Cygni.
15	(7 $57\frac{1}{4}$ p.m.)	Boston, U.S.A.	As bright as Jupiter.	. . .	Rapid . .	From $316° - 3\frac{1}{2}°$ to $325° - 8°$ near β Aquarii.
21	(9 $19\frac{1}{4}$ p.m.)	Ibid. . .	As bright as Venus	Green . .	1·5 sec. in sight; very slow.	From $5° - 15°$ to $343° - 32°$.
22	7 40 p.m.	Sunderland .	At first = 2nd mag. * expanded to $> ♀$.	At first orange, then changed to yellow, green, and pale purple.	3 secs.; very slow.	Shot 2° past a point at $\frac{1}{2}°$ (o Tauri, α Ceti) from a point (ill seen) about $\frac{1}{2}°$ (β Trianguli, 41 Arietis).
22	(6 $59\frac{3}{4}$ p.m.)	Boston, U.S.A.	As bright as Jupiter.	Orange .	3·5 sec.; rather slow.	From $16° - 1°$ to $34° + 7°$.

OBSERVED, CHIEFLY IN THE YEARS 1878–1879—*continued.*

Length of Path	Direction or Radiant-point	Appearance, Remarks, &c.	Observer or Reference
. . .	. . . . .	Nucleus pear-shaped, thus, throwing off several sparks above it.	J. Hopper.
5° . .	Fell vertically; near β Ceti	Left no streak	E. F. Sawyer. Boston 'Science Observer,' vol. ii. p. 26.
. . .	An Aurigid; radiant on this night at 87°+42°, near β Aurigæ.	Left streak 7° long on the latter part of its course.	W. F. Denning. 'The Observatory,' vol. ii. p. 243.
10° . .	Directed from γ Andromedæ	. . . . .	E. F. Sawyer. Boston 'Science Observer,' vol. ii. p. 27.
. . .	. . . . .	. . . . .	Communicated by W. F. Denning. 'The Observatory,' vol. ii p. 243.
. . .	. . . . .	The meteor at starting was not much brighter than Saturn, but when bursting at last into several sparks (which fell downwards about 1°), it threw shadows in spite of the moon, then 11 days' old.	Id. Ibid.
About 25° of its course seen.	Directed from 2 (δ, γ) Ursæ majoris.	Nucleus with only a very short, if any, train. No meteor seen before to last so long.	T. W. Backhouse.
. . .	. . . . .	Beginning not seen; diminished to a mere point at last; left no streak.	T. Brewin. (Communicated by G. L. Tupman.)
10° . .	. . . . .	. . . . .	E. F. Sawyer. Boston 'Science Observer,' vol. ii. p. 27.
27° . .	. . . . .	From $\frac{1}{3}$ (β ι) Ceti to near Fomalhaut.	Id.
. . .	. . . . .	Vivid green, with a faint train, when brightest, casting a glow all round. Faded 2° before extinction to brightness of Sirius, and disappeared rather suddenly. A splendid meteor.	T. W. Backhouse.
9° . .	. . . . .	Seen through haze . . .	E. F. Sawyer. Boston 'Science Observer,' vol. ii. p. 27.

A List of Large Meteors occasionally

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration	Position or Apparent Path From α δ	to α δ
	h m						
Sep. 22	(9 7¼ p.m.)	Boston, U.S.A.	As bright as Jupiter.	. . .	Slow . .	From 3°−10°	to 346°−28°.
24	(Evening)	Stanislas, Austria.	Thrice as bright as Jupiter.	Violet colour	. . .	In Ursa Major	
Nov. 2	6 43 p.m.	York . .	Disc larger than Venus'. Dazzlingly bright.	. . .	. . .	From 28° W. of N. alt. 18°	to 60° W. of N. alt. 13°. Positions measured (Azth.'s magnetic).
3	12 57 a.m.	Greenwich .	Brilliant meteor. Lighted the Park up brightly.	Yellow .	3 seconds at least; slow, sailing motion.	Part of path in sight 310°+61°	to 266°+42°; probable beginning at 0°+58°, about γ Andromedæ.
12	(7 0 p.m.)	Washington, Davies's Co. Ind. U.S.	About ⅔ apparent diam. of the moon.	. . .	About 10 seconds; very slow.	From close to Vega across the Milky Way	to about 20° N.W. of Jupiter.
12	(7 15 p.m.)	Boston, U.S.A.	= Sirius . .	. . .	. . .	From N.E., alt. 30°	to N.W. alt. 30°; highest point of apparent path due N.
13	(6 40 p.m.)	Newhaven, Mass. U.S.	= 1st mag. *.	. . .	1 or 1½ seconds.	From a little N. of Vega	to a little S. of χ Ophiuchi.
14	(3 30 p.m.)	Hillside Farm, Mass. U.S.A.	Fine meteor .	. . .	. . .	. . .	. . .
18	9 50 p.m.	Bristol . .	As bright as Jupiter.	. . .	Very slow .	47−26½	to 50−27½ low down in S.S.E.
18	9 50 p.m.	Writtle, near Chelmsford, Essex.	As bright as Venus.	. . .	. . .	11−22	to 17−30 low down in S.
Dec. 6	12 13 a.m.	London, or Greenwich (?)	A fine meteor .	Bluish white	. . .	Shot under, and a little past, Sirius, ⅔ of that star's alt. from the horizon.	
11	(6 a.m.)	Mülhausen, and Colmar, &c., Alsatia.	Large fireball .	. . .	. . .	From N.W.	to S.

OBSERVED, CHIEFLY IN THE YEARS 1878-1879—*continued.*

Length of Path	Direction or Radiant-point	Appearance, Remarks, &c.	Observer or Reference
5°; long path	. . . . .	From ι Ceti to Fomalhaut; train visible for 1 sec.	E. F. Sawyer. Boston 'Science Observer,' vol. ii. p. 27.
. . .	Moving in a northerly direction.	Meteor with a reddish train .	'Nature,' vol. xix. p. 17.
bout 30° .	Moved almost horizontally southwards.	Like a rocket or Roman candle, ball close at hand. End of path apparently depressed; left no streak.	J. C. Morland and J. E. Clark. 'Nat. Hist. Jour.' vol. ii. p. 145.
. . .	. . . . .	From γ Andromedæ, across α, η Cephei to under and 4° left of γ Draconis, half that star's altitude from the horizon. A flash all round (before reaching α Cephei?) made the observer look up to it, after which it was = Sirius, leaving a streak for 2 seconds.	A. W. Downing. (Communicated by G. L. Tupman.)
. . .	. . . . .	Nucleus with sharply defined disc up to the moment of its disappearance. Seen while watching with students for November meteors.	D. E. Hunter; D. Kirkwood. 'Am. Phil. Soc. Proceedings,' May 2, 1879.
. . .	. . . . .	A smaller meteor broke off from it, just before its crossing the square of Ursa Minor, and continued parallel to and ½° above it till both disappeared together as suddenly as the meteor first appeared.	H. E. Stevens. Boston 'Science Observer,' vol. ii. p. 30.
. . .	. . . . .	. . . . .	J. J. Skinner. (Communicated by H. A. Newton.)
. . .	. . . . .	The sky was very clear, and the meteor was seen in bright sunshine.	Thomas Whitaker; D. Kirkwood. 'Am. Phil. Soc. Proceedings,' May 2, 1879.
ery short; only the end seen?	Radiant of the two projected paths, near λ Piscium, 354 + 1.	Left no streak. [Identical with the next meteor; see calculated real path in Appendix I.]	W. F. Denning. 'The Observatory,' vol. ii. p. 306.
. . .	The same radiant observed by Denning (350° + 2°) on Dec. 1-2, 1877.	. . . . .	H. Corder. Ibid.
. . .	Nearly parallel to, but more horizontally than, a line drawn from Rigel to Sirius.	[Seen also by Dr. Rae (in London?): 'Nature,' Dec. 12, 1878.]	W. Airy. (Communicated by G. L. Tupman.)
. .	. . . . .	Burst, exhibiting a display of natural fireworks. No sound of an explosion heard.	'Nature,' vol. xix. p. 160.

A List of Large Meteors occasionally

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration	Position or Apparent Path From α δ to α δ
	h m					
Dec. 11	9 36½ p.m.	Sunderland .	About as bright as Jupiter.	White, then green, and variable at last.	. . .	Disappeared about ¼ (53, γ) Eridani.
18	8 57 p.m.	Thames Embankment, London.	About thrice as bright as Jupiter.	. . .	2·5 seconds .	Started exactly at γ, and passed 2° or 3° E. of ζ Orionis.
19	(9 29½ p.m.) (8 p.m.)	New Haven, Mass., U.S.A.	Brighter than a 1st mag. *.	. . .	3 seconds .	From close to the 'crab' nebula to just above and left of α Ursæ majoris.
21	9 33 p.m.	Bristol . .	Brighter than Venus.	. . .	. . .	13—5 to 11—19.
25	(8 p.m.)	Boston, U.S.A.	As bright as Jupiter.	. . .	3 or 4 seconds; moved very slowly.	Appeared in the S.W., alt. 23°; altitude at disappearance 18°.
30	Just before 7 p.m., Indianapolis time.)	Wooster, Wayne Co., Ohio. [Widely seen; and also well observed at Anderson (Ind.), and Washington (Pa.).]	Transverse diam. of disc = ½ diam. of the moon.	[Slightly greenish; reddish when bursting.]	[About 2 seconds, or a fraction less.]	From E., alt. 50°, to S. 13° E., alt. 13°, exploding S. 33° E. (measured positions; the first very accurate).
1879 Jan. 12	(9 56 p.m.)	The Observatory, Moncalieri, near Turin.	Large disc about 7′ diam., giving stronger illumination than the moonlight.	Nucleus gold yellow; vapour-envelope, and train greenish and bluish white.	About 3 seconds.	Skirted the line of stars α, ρ, χ, and disappeared near σ Leonis.
13	(6 5 p.m.)	Boston, U.S.A.	Much brighter than Venus.	Deep yellow.	Shot very slowly.	First appearance a little E. of N., alt. about 60°. Disappeared behind a cloud bank.
15	10 57 p.m.	Newcastle-on-Tyne.	Brighter than Venus.	. . .	. . .	From about 2° E. of β Ursæ majoris to the Præsepe in Cancer.
28	(2 28 a.m.)	Traverse City, and other places in Wisconsin and Michigan,	Larger than (3 or 4 times as large as) the full moon.	A ball of fire (white, then reddish illumination;	Speed of a descending rocket. (About 8 or 10 seconds;	Observer facing due E. first saw it as high as an ordinary rain-cloud over his

OBSERVED, CHIEFLY IN THE YEARS 1878–1879—*continued.*

Length of Path	Direction or Radiant-Point	Appearance, Remarks, &c.	Observer or Reference
About 25° .	Course a little curved downwards (?), directed from $\frac{1}{5}$ (γ Orionis, α Arietis).	Faded gradually at last; left a slight train.	T. W. Backhouse.
About 30° .	Full almost vertically (inclined 3° towards the left, by a diagram).	Left a few detached pieces in its track; it seemed to hesitate, and then die out.	W. Wickham. (Communicated by G. L. Tupman.)
. . .	. . . . .	A very bright meteor . .	J. J. Skinner. Boston 'Science Observer,' vol. ii. p. 35.
. . .	. . . . .	Nucleus became faint, before the maximum, then suddenly increased to a vivid flash, leaving a streak there, 1° long, for 7 seconds, at the end of its course.	W. F. Denning. 'The Observatory,' vol. ii. p. 346.
25° . .	Shot towards E. . . .	. . . . .	N. M. Lowe. Ibid. p. 43.
. . .	. . . . .	Nucleus very elongated. First part of course very accurately noted through large tree-tops. [See description of its real path in Appendix I.]	S. J. Kirkwood; D. Kirkwood, 'Am. Phil. Soc. Proceedings,' May 2, 1879.
. . .	. . . . .	A bright blue streak marked the meteor's path after the disappearance of the nucleus for a second or two.	P. Denza, and other observers. 'Astronomical Register,' vol. xvii. p. 150.
30° . .	Shot almost vertically downwards.	. . . . .	James E. Stone. Boston 'Science Observer,' vol. ii. p. 43.
. . .	[Probable radiant near α θ Draconis; Denning.]	Left a thin vapour-like streak for 2 or 3 seconds stretched along a line from above the stars of Leo.	'The Observatory,' vol. ii. p. 383. (Meteor notes by W. F. Denning.)
. . .	It was moving on a descending grade when first seen.	Just after passing the east, a perfectly distinct ring of fire with a dark centre peeled off it, and dropping a little behind it, followed the nucleus	Report of a night watchman, communicated by T. T. Bates; D. Kirkwood, 'Am. Phil. Soc. Pro-

A List of Large Meteors occasionally

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration	Position or Apparent Path From α δ to α δ
	h m	U.S. [For a description of its real path see Appendix I.]		Princeton).	Princeton, Wisconsin)	right shoulde in S.W., and i passed by hin to N.E. on hi left.
Feb. 3	(11 30 p.m. Ind. time.)	Raysville, Henry Co., Ind., U.S.	Larger than the fireball of Dec. 21, 1876.	. . .	Brief duration; only a few seconds.	Rose from th eastern horizon and burst jus before reaching the zenith, th fragments no proceeding very far.
8	6 59 p.m.	Birkdale Observatory, Southport.	Brighter than Venus.	Red . .	Quick motion.	From $7\frac{1}{2}° + 32°$ to $342\frac{1}{2}° + 62°$.
20	6 43 p.m.	Putney Hill, London.	As bright as Rigel.	White, or yellowish.	2–3 seconds .	From $25° + 40°$ to $32° + 35°$.
22	About 12 20 a.m.	Bury St. Edmunds (and elsewhere in Surrey, Essex, and Suffolk). [See description of the real path in Appendix I.]	Large fireball. (Lit up a room facing south, at Godalming, Surrey.)	(Brilliant white, then pink, then green; Brentwood, Essex.)	(20 seconds, Saffron Walden. 5 or 6 seconds, Godalming and Haverhill. Several seconds. Brentwood.)	In the west, falling downwards to the earth. (The glare in the cloudy sky was strongest in the S.E., at Haverhill, and at Saffron Walden, a little S.E. of the zenith. At Brentwood the track passed overhead.)
23	About 6 45 p.m.	Kersal, near Manchester	Brilliant meteor .	. . .	Moved slowly; time to call another person's attention to it.	'At a small angle' just below the new moon.
24	2 53 a.m. (York Minster time.)	York (four or five good observations among numerous descriptions). [The next observation to this refers to the same meteor.]	$\frac{1}{6}$ to $\frac{1}{2}$ the moon's diameter, with a haze or 'glory' round it 4 × the moon's diameter.	White, changing to blue, or bluish green.	'2 seconds.' '3 or 4 seconds, &c.' Perhaps about 6 seconds, at full brightness, from general accounts.	Passed from N.E. (probably a little S. of the zenith), nearly overhead, to a point (measured by the towers of the Minster) at 41° W. for S. (true). Alt. 10° (Other notes were 53° and 48° W. for S.)

OBSERVED, CHIEFLY IN THE YEARS 1878–1879—*continued.*

Length of Path	Direction or Radiant-point	Appearance, Remarks, &c.	Observer or Reference
		out of sight. The report followed the meteor's disappearance in just 4 minutes by a watch.	ceedings, May 2, 1879.
. . .	Rose upwards; E. to W. .	Extremely large, followed by a stream of flame, and bursting at last into fragments which shot earthwards in various directions, with a dull but distinctly audible report.	Indianopolis 'Daily News,' Feb. 7; D. Kirkwood, ibid.
. . . . .	. . . . .	A fine meteor. First seen appearing from above the house; burst at last into numerous brilliant fragments.	Communicated by Jos. Baxendell.
. . . . .	. . . . .	Projected a smaller body some 5′ or 6′ in front of its nucleus, near the end of its flight.	J. L. McCance. 'The Observatory,' vol. ii. p. 417.
. . .	Fell downwards. (Course at Saffron Walden, from S.W. to N.E.; at Brentwood from S.S.W. to N.N.E.)	Lit up the sky vividly. (Burst into a shower of sparks; Brentwood. The glare increased gradually, ending with a sudden blaze; Godalming.) Report like that of an explosion (heard like thunder at Haverhill in 30 secs. or 45 secs., rumbling down to N.W. from alt. 45°. A rumbling sound in 20 secs. heard at Saffron Walden.)	'The Observatory,' vol. iii. p. 22. 'Nat. Hist. Journal,' vol. iii. p. 68. (V. Cornish, W. F. Denning, J. E. Clark.)
. . .	'Descending at a small angle;' course about from north to south.	Had the night been dark it would have been a grand fireball.	A writer in the 'Manchester Guardian,' Feb. 27 (or 26?) 1879.
. . .	About N.E. to S.W., passing (?) a little southward from the zenith.	Pear-shaped, followed by a tail two or three times the length of the head, leaving no streak upon its track. Burst when over-head with frequent sparks and scintillations; but at the end of its course the ball 'disappeared in mid-air.' Light like daylight, effacing street lamps, and stronger than the electric light. Report like a sudden 'bang' in $1\frac{1}{4}$ or $1\frac{1}{2}^{m}$, like	Accounts of several observers, collected by J. E. Clark. Notes in the 'Observatory,' vol. ii. p. 417; and 'Nat. Hist. Journal,' vol. iii. pp. 69–70.

A List of Large Meteors occasionally

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration	Position or Apparent Path From α δ to α δ
	h m					Beginning doubtful; apparently about 14° N. of E. Alt. 58° (?)
Feb. 24	About 3 0 a.m.	At sea, 2 miles N.W. from Whitby (and at Hull). [Seen also at Brighton, Birmingham, Manchester, Liverpool, and Dundee. For real path see Appendix I.]	(Nucleus not more than ½ diameter of moon. Tail not more than 4 × the length of the head. Hull.)	(Primrose yellow. Nucleus with prismatic tail. Hull.)	Light 1 second before, and nucleus seen 10 seconds after its first clear appearance.	From 20° E. of N.; alt. 45° to 20° W. of S.; alt. 45° (first and last appearance among snow-clouds.) (At Hull, seen from 4° W. of N.; alt. 60° (?) to 4° N. of W.; alt. 20° (?) (directions by a map.)
Mar. 2	6 15 or 20 p.m.	Winchester .	About ⅓ of full moon's size	Yellowish, surrounded by red light	. . .	From 70° – 20° „ 85° – 25° (end point hidden by trees).
2	8 45 p.m.	Sidcot . .	Bright; = Regulus.	. . .	. . .	Began at ½ (α Leonis, α Hydræ.)
2	9 40 p.m.	Debenham, Norfolk.	Bright; = 1st mag. *	. . .	. . .	From 184° + 63° to 18½° + 58°
3	. . .	Sunderland .	Bright; = Sirius.	Deep yellow; tail reddish	4 or 5 seconds; very slow. No ↓ before seen with such a long duration.	From 140° – 7° to 160° – 7°
8	7 20-25 p.m.	Bristol . .	As bright as Jupiter.	. . .	Rapid . .	Centre of course at alt. 18°, S.S.E.
9	(Evening)	Newhaven, Mass., U.S.A.	Bright meteor .	. . .	. . .	From 55° W. of S.; alt. 30° to 25° E. of S.; alt. about 15°.
12	7 37 p.m.	Greenwich .	Brighter than Venus.	Green . .	Very swift; not more than (?) 1 second.	From 205° + 35° to 196° + 6°.
12	7 35 p.m.	Bristol . .	. . . .	. . .	Motion slow .	From 210° + 40° to 197° + 7°. Apparent path as described to Mr. Denning.

OBSERVED, CHIEFLY IN THE YEARS 1878–1879—*continued.*

Length of Path	Direction or Radiant-point	Appearance, Remarks, &c.	Observer or Reference
		an earthquake shock, which died away slowly.	
. . .	. . . . .	Began like moonlight in N.E. Dense luminous train, with dropping sparks. Faint report like distant thunder. (Report at Gunby, near Filey, intense; not quite so strong as loudest thunder. At Hull, fainter, heard in 2^m.)	E. Heselton (of ship 'Margery; Seaham to Scarborough.) Communicated by J. E. Clark.
. . .	. . . . .	Nucleus quite round . .	Communicated by J. L. McCance, in 'The Observatory,' vol. ii. p. 417.
5° or 6° .	Towards S.E. . . .	Two minutes later a rather brighter meteor appeared at the same place, with a course of 2° towards S.S.E.	C. E. B. 'Nat. Hist. Journal,' vol. iii. p. 50.
. . .	. . . . .	The meteor burst $\frac{1}{4}$° np. δ Ursæ majoris.	V. Cornish, 'The Observatory,' vol. iii. p. 22.
25° . .	. . . . .	Increased in brightness constantly, with some fluctuations, till it disappeared. The sparkling tapering tail, 2° or 3° long, was brightest near the nucleus. A fine meteor.	J. W. Backhouse.
Rather long path.	Descending obliquely towards S.E.	Train	Communicated by W. F. Denning. 'The Observatory,' vol. iii. p. 417.
. . .	. . . . .	. . . . .	Communicated by H. A. Newton. Boston 'Science Observer,' vol. ii. p. 51.
. . .	. . . . .	A fine meteor; seen through clouds and haze.	W. H. M. Christie. Communicated by G. L. Tupman.
. . .	. . . . .	Seen by two gentlemen, who immediately described its course to Mr. Denning.	Communicated by W. F. Denning.

A LIST OF LARGE METEORS OCCASIONALLY

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration	Position or Apparent Path From α δ to α δ
Mar. 15	h m (3 53 a.m.)	Washington, Davies's Co., Ind., U.S.A.	. . . .	Pale bluish colour.	. . .	First seen at a point 10° W. of S., alt. 25°.
Apr. 18	8 52 p.m.	Sandymount, Dublin.	Bright shooting star.	. . .	About 5 seconds; rather slow speed.	From Arcturus towards, and to within 10° or 12° of Procyon.
19 [? 18]	About 9 p.m.	Birmingham .	Bright meteor .	. . .	. . .	Shot from near η Ursæ majoris to a point about E.S.E., alt. 40°.
19	12 50 a.m.	Bristol . .	Brighter than 1st mag. ∗.	Nucleus with train of yellow sparks.	6 seconds; extremely slow motion.	From 310° + 51° to 263° + 48°.
21	8 43½ p.m.	Bath . .	Fireball . .	. . .	. . .	Disappeared 3° or 4° S.E. of Procyon.
21	8 43 p.m.	Bristol . .	As bright as Venus.	. . .	. . .	Began at a considerable altitude in the southern sky.
June 7	About 10 p.m.	Geneva (Neuchatel, Zug, Milan, &c.).	As large as full moon.	Greenish, with iridescent colours.	. . .	. . . . .
18	10 38 p.m.	Bath . .	Like a 'fireball' of a firework.	Colours decidedly bluish green.	2–3 seconds.	First appeared about 10° S. of Arcturus.
18	10 57	Bristol (seen by several observers).	Large disc. .	. . .	. . .	. . . . .
July 27	(12 45 a.m.)	Droeda, Saxony. (Similar accounts from Leipzig, Dresden, Zwickau, Wiedersberg, &c.)	Large fireball .	Bright blue.	3 seconds; moved slowly.	Across the heavens.
27	1 36 a.m.	Bristol . .	As bright as Mars.	Yellow .	Very slow motion.	From 180° + 75° to 152° + 73°.

OBSERVED, CHIEFLY IN THE YEARS 1878–1879—*continued.*

Length of Path	Direction or Radiant-point	Appearance, Remarks, &c.	Observer or Reference
20° . .	Moved westwards . .	Burst at last into fragments, and lighted up everything almost like daylight. Left a smoke-cloud visible for several minutes.	Several observers. Communicated by D. E. Hunter; D. Kirkwood, 'Am. Phil. Soc. Proceedings,' May 2, 1879.
Nearly 65° .	Almost due E. to W. . .	Disappeared without explosion, or any other peculiarities of appearance in its course. No meteor before seen with such an extended course.	J. O'Reilly. Communicated by R. S. Ball.
Long course	. . . . .	Noted while viewing the stars; as remarkable, apparently, for its long course. [? if identical with the last meteor.]	'Aster.' Birmingham 'Daily Post,' Apr. 22, 1879.
About 30° .	. . . . .	A fine meteor, with bright train of sparks.	W. F. Denning, 'The Observatory,' vol. iii. p. 56.
. . .	Directed from α Leonis .	Attention drawn to the meteor from a direction facing east, by a sudden brightness of the sky. Explosion like that of a fine rocket.	J. L. Stothert, ibid.
. . .	Descended obliquely towards the west.	Unusually large and brilliant; seen by many persons in Bristol.	Bristol Newspaper, April 22. Communicated by W. F. Denning.
. . .	Its entire course was sinuous, presenting a strange zig-zag form. From N.E. to S.W. (?).	A report heard in the Valaisan Alps, and at Vittore Olona, Lombardy; a report like artillery followed its disappearance in about 4 minutes ('The Times'). An aërolite (?) fell at the same time in Lake Lugano.	'Nature,' vol. xx. p. 183.
About 25° .	Very nearly N.E. to S.W. .	Left a faint trail. The decided colour of its nucleus was remarkable.	C. Armbruster, 'Nature,' vol. xx. p. 197.
. . .	Course 'almost a straight line' from S. to N.	A beautiful meteor, with immensely large nucleus, leaving very little tail behind it. Attracted attention by its light illuminating the ground.	Bristol Newspaper; W. F. Denning's notes in 'The Observatory,' vol. iii. p. 117.
. . .	Moving from S. to N. . .	Illumination of the whole firmament; nearly as intense as daylight.	'Nature,' August 14, 1879.
. . .	Radiant near η Draconis .	Left a train of sparks . .	W. F. Denning.

A List of Large Meteors occasionally

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration	Position or Apparent Path From α δ to α δ
July30	12 16 a.m.	Bristol . .	As bright as Jupiter.	. . .	Rapid . .	From 140° + 66° to 158° + 54°.
Aug. 9	11 53 p.m.	Ibid. . .	As bright as Jupiter.	. . .	Rapid . .	From 34° + 78° to 254° + 85½°.
11	11 30 p.m.	Ibid. . .	As bright as Jupiter.	. . .	Rapid . .	From 6° + 47° to 351° + 37°.
11	11 55 p.m.	Ibid . .	As bright as Mars.	. . .	Slow . .	From 30° + 64° to 50° + 54°.

SUPPLEMENTAL ACCOUNTS OF LARGE METEORS

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration.	Position or Apparent Path
1858. Aug.13	h m Not noted, but about 6 p.m. (?). [True time 6 39 p.m.]	1 or 2 miles E. of Ryde, I. of Wight.	At first $\frac{1}{6}$ of the moon's diameter, but increased as it advanced. Eclipsed the light of the stars and of the moon (which was unusually bright).	At first ruddy, then pure white; tail bluer, with faint prismatic colours. [Streak white ?]	Nearer 5 than 3 seconds; speed very moderate, smooth and uniform.	From near E.S.E., alt. about 15°, to near S.S.E., alt. about 20°; centre of course due S.E.
1877. Oct. 9	12 12 a.m. (Paris time; = 12 3 a.m. G.M.T.)	Charleville, near Mezières, Ardennes, France (and Antwerp). [See calculation of the real path; Appendix I., Supplement.]	Very bright fireball.	. . .	Rather long duration; 3–5 secs.	Made its appearance in the north. (In the north.)

OBSERVED, CHIEFLY IN THE YEARS 1878–1879—*continued*.

Length of Path	Direction or Radiant-Point	Appearance, Remarks, &c.	Observer or Reference
. . .	A Perseïd II. . . .	Left a streak	W. F. Denning.
. . .	A Perseïd I.	Left a streak. In 2^h, 45 meteors seen, nearly a half of them Perseïds I., radiant, exact at $46° + 58°$.	Id.
. . .	A Perseïd I.	Left a streak. Perseïds more numerous (3 : 1) than other meteors; rate of all meteors at 10 p.m., 72 per hour.	Id.
. . .	Radiant in Cepheus or Lyra	Left a bright train. Perseïds and other meteors about equally frequent on Aug. 12, p.m. A good radiant, Aug. 9–12, at $46° + 58°$.	Id.

OMITTED IN THE ABOVE GENERAL LIST.

Length of Path	Direction or Radiant-point	Appearance and Remarks	Observer or Reference
45° or 50° .	At first nearly stationary, then slightly ascending for $\frac{3}{4}$ and descending for $\frac{1}{4}$ of its track. General form and breadth of the head and streak.	Nucleus a 'ball' throughout, with a short tail almost as bright, and a long, somewhat wavy and inflated-looking streak following it on $\frac{3}{4}$ (or at last on only $\frac{1}{4}$ or $\frac{1}{5}$) of its track. The whole, short tail and nucleus together, vanished suddenly at last. A magnificent meteor. [Seen also in London by Mr. Pope Hennessy; these Reports, vol. for 1858. p. 152.—Radiant about $335° + 5°$ ($\pm$ 4°).]	F. Caws. Communicated by H. R. Procter.
. . .	(Descending towards N.W.)	Left behind it a long streak, which remained visible for six seconds. [Seen also at Bristol; these Reports, vol. for 1878, p. 282. Mr. Denning's radiant is confirmed by the Antwerp track, at $77° + 34°$.]	Mons. Thibout; 'Bulletin hebd. de l'Assoc. Scientifique de France,' xxi. (1877–78), p. 63.—(Mons. de Boë; ibid.)

SUPPLEMENTAL ACCOUNTS OF LARGE METEORS

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration	Position or Apparent Path From α δ to α δ
Oct. 14	About 6 15–20 (Paris time).	Neuilly Enthelle, Oise (and d'Oissel Station, Rouen to Elbœuf), France.	A fine bolide rather than a shooting-star. Large size; light like a lightning flash.	(White; the fragments red.)	. . .	In the West. ['Shot from near Ursa major towards the left;' description in Paris giving no time.]
14	About 6 55 p.m. (Paris time).	Clermont Ferrand (and Dijon, Vincennes, Paris, Arras, Yvetot, Autheuil in Eure; Courville, Eure and Loire; St. Honorin du Fé, Manche).	Between the brightness of Jupiter and Venus ($\frac{1}{3}$ of the moon's diameter at last, in Paris; light stronger than moonlight).	Colour decidedly green. (Bright pale-green, Dijon; blue, Vincennes. White with red and blue tail and fragments; Arras, Yvetot, Paris.)	Scarcely 2 seconds. (4–6 secs., slow; Yvetot, and Paris.)	From 1° prec. α Ursæ majoris to the horizon. ('Across' the sky, Yvetot. 'Perpendicularly to Corona,' Autheuil. Ended at 22° + 12°, beginning less certain, at 14° + 45°, St. Honorin du Fé. Began at η Ursæ majoris and fell vertically, Dijon. Began a little west of, and shot away from, Ursa major, Courville.)
14	About 8 p.m. (Paris time).	Rubernpré, near Amiens, France.	Size of a shooting-star.	Colour of an ordinary shooting-star.	. . .	Seen from a north door; shot quite across the constellation Ursa major.
1878. Jan. 12	9 25 p.m. (Paris time).	Damblain, Vosges, France.	$\frac{1}{10}$ diam. of the moon.	Bluish at last, and green at bursting.	Time of flight, some 80 secs. [?]	Began in Lyra, and shot towards Saturn, disappearing just above Aquila.
Feb. 4	10 15 p.m. (Paris time).	Ibid. . .	$\frac{7}{10}$ of the moon's diameter.	. . .	Rather slow speed.	'Appeared in the N.N.E. and shot towards the S.S.W. Altitude of its course about 25°.'
20	10 40 p.m. (Paris time).	Between Nogent and Chaumont, France.	$\frac{1}{6}$th of the moon's diameter.	Vivid green at bursting.	Long duration; about 60 secs. (?)	Began near δ, ε Cassiopeiæ, passed near θ and α, and across β and ν Persei, but to the right of χ Persei, bursting near the Pleiades.

OMITTED IN ABOVE GENERAL LIST—*continued.*

Length of Path	Direction or Radiant-point	Appearance and Remarks	Observer or Reference
. . .	. . . . .	Burst like a bomb-shell. (Broke into pieces at last; lit up the railway carriage in spite of strong moonlight.) [Perhaps identical with the next meteor (?)]	See the next meteor.
. . .	Directed exactly from Polaris. (Going towards W., with a slight inclination from S.E., Arras. — Shot from near Ursa major 'towards the left;' fell 'almost vertically,' a little inclined 'from left to right' (?), and 'from N.W. to S.E.' (!), Paris; 'in direction of Boul. Sebastopol, beginning over the Théatre de Renaissance,' Boul. de St. Martin, Paris. Fell vertically at Dijon.)	Increased rather than diminished constantly in size as it neared the horizon. (Nucleus a kite-shaped body, with blue and red vapour round it, and a very broken flickering tail; expanded gradually until it burst into many fireballs or fragments, leaving a blue streak for a few seconds only; Yvetot, Autheuil and Paris. Moved, as it fell, by jerks, Dijon; or like a drop of gum in water, Paris.)	Accounts collected by the Paris Observatory and by the 'Association Scientifique de France.' ('Bulletin hebdomadaire' of the 'Association,' tome xxi. p. 205.)
Very long course.	From E. to W. . . .	Three minutes later another meteor near Algol shot towards Auriga, and disappeared quickly.	Ibid.
. . .	. . . . .	Left no streak; no sound of an explosion audible.	Mons. Guyot; 'Comptes Rendus,' vol. 86, p. 729.
. . .	. . . . .	Left a reddish streak; and disappeared without bursting. But about two minutes after its first appearance, a distant sound was heard like that of waggons rumbling on a pavement.	Id.; ibid.
. . .	The track and final deportment (even to the tracks taken by the three fragments at last) of the bolide of Dec. 20, 1871, at Nancy ('C.R.' lxxxiv. p. 202), were identical with this.	Left no streak. At bursting, one fragment shot towards δ Tauri, another towards, and disappeared near, θ Aurigæ; and a third moved westwards and disappeared in Aries. The bolide of Dec. 20, 1871, was also green at bursting, and it left no streak.	Id. Ibid. [For fireballs of Dec. 20, 1871, Nancy, and Dec. 20, 1870, Hawkhurst, see these 'Reports,' vol. for 1872, p. 112, and vol. for 1871, p. 32.)

SUPPLEMENTAL ACCOUNTS OF LARGE METEORS

Date	Hour Approx. G.M.T. (or Local Time)	Place of Observation	Apparent Size	Colour	Duration	Position or Apparent Path From α δ to α δ
July 12	8 30 p.m. (Paris time).	Privat, Ardêche, France.	Large . .	Light vivid blue.	. .	. . . .
26	10 38 p.m. (Paris time).	Montrouge, Paris (?).	. . . . .	. . . .	. . .	The streak lay a little E. of the zenith, extending from N.E. to N.W. (? S.W.)
Sep. 2	9 35 p.m.	Wonersh, Guildford, Surrey.	Twice or thrice as large as Jupiter.	Green, like burning silver, changed to red in bursting.	About 3 secs.; moved slowly.	From $272\frac{1}{2}° - 10°$ to $255° - 16°$ (disappearance close to η Ophiuchi).
6	About 9 10 p.m. (Berlin time.)	Hanau (and many other places in) Germany.	. . . . .	. . . .	Whole duration of the phenomenon about 30 secs.	Appeared in the S.E.; a solid-looking nucleus and long tail stretching to N.W.
15	Between 6 and 7 p.m. (Local times).	Tenez (and Constantine, and many other places in) Algeria. And the same meteor (?) also at Montpellier, France.	Very brilliant fireball.	. . . .	Very long duration.	. . . .
Oct. 17	(About 5 50 p.m.)	Harlton, Cambridge.	. . . . .	Bright green.	About 2 secs.; motion rapid.	Fell quite close to the moon.

OMITTED IN ABOVE GENERAL LIST—*continued.*

Length of Path	Direction or Radiant-point	Appearance, Remarks, &c.	Observer or Reference
. . .	. . . . .	A magnificent fireball; broke into several pieces.	'Nature,' vol. xviii. p. 318.
Length of the streak 10° or 12°.	. . . . .	Shortly after a brilliant flash, which lighted up everything, the streak which it left was seen, and remained visible for 6 or 7 secs. Cloud and haze hid the stars. No sound heard.	Th. Moureaux. 'Bulletin Hebdomadaire de l'Assoc. Scientifique de France,' vol. xxii. p. 272.
. . .	Fell towards the S.W. horizon.	Large meteor; broke up, or fell to pieces at the end of its course. Attention drawn to it by its light while looking for Jupiter in a telescope.	Sydney Evershed, 'Nature,' vol. xviii. p. 519.
. . .	. . . . .	Appeared with a flash like lightning; the comet-like tail remaining when the nucleus had disappeared, and little stars being visible through it with the naked eye.	Ibid. p. 575.
. . .	. . . . .	Whether all the accounts refer to the same fireball is not certain. A sound accompanied it at Constantine.	Ibid.
Long path .	Descending almost perpendicularly, but inclined a little from N. to S. as it fell.	Most brilliant, even in strong moonlight and daylight, shortly after sunset.	O. P. Fisher. Ibid. p. 643.

LARGE METEORS IN 1878-9, OBSERVED

Date	Hour	Place of Observation	Apparent size	Colour	Duration	Position, or Altitude and Azimuth
1878. March 2	h m About 9 45 p.m.	Near Chelmsford.	Brighter than Venus.	Orange .	Not very slow	In S. (E. of and under Orion).
Nov. 18	9 50 p.m.	Writtle . .	= ♀ . . .	Green . .	2 secs. (?) .	From 11°−22° to 17°−30°.
Dec. 18	About 9 0 p.m.	Chelmsford .	Brighter than Venus.	. . .	Not very slow	From a little W. of Rigel to near the horizon.
18	6 5 p.m.	Ibid. . .	1st . . .	. . .	Moderate .	From 311°+27° to 313+20°.
21	About 3 30 p.m.	Ibid. . .	Fireball . .	. . .	. . .	Fell downwards in N. (?)
1879. Aug. 4	11 5 p.m.	Writtle . .	= ♃ . . .	Emerald green.	2 or 3 secs. .	From 245°+62° to 207°+52°.
6	10 20 p.m.	Broomfield, near Chelmsford.	= ♃ . . .	Emerald green.	2 or 3 secs. .	From 114°+46° to 115°+38°.
11	10 50 p.m.	Writtle . .	= Sirius . .	Orange .	1 sec. . .	From 194°+70° to 203°+58°.
11	12 25 p.m.	Ibid. . .	Brighter than Venus.	Green (?) .	0·2 sec. (?) .	From 50°+14° to 51°+7°, *very* doubtful.

NEAR CHELMSFORD. By H. Corder.

Appearance; Train or Sparks; Streak, if any left, and its Duration	Length of Path	Radiant-point; Direction; Slope of Path.	Remarks	Observer
Disappeared with bright flash behind clouds.	. . .	Somewhat in this position probably:—	. . . . .	Mrs. J. C. Smith.
Short spark train; began with flash.	8° . .	. . . . .	[See the above general list.]	H. Corder.
Left a long streak; and bright enough to light up sky and road.	. . .	Probable path:—	Not seen by a regular observer, so description vague. A bright 1st mag. streak-leaving meteor at about 6.5 the same evening. (See the next observation.)	J. King.
Left a streak . .	. . .	. . . . .	Possibly same radiant as the last meteor.	H. Corder.
Bright in daylight .	. . .	. . . . .	No stars out to map .	E. H. Christy.
? Short train . . .	10° or 12° .	? From Cygnus, about 295° + 55°.	Exactly similar in every respect.	H. Corder.
„ . . .	„	„		Id.
Fine streak . . .	. . .	Perseid . . .	Two others 1st mag. almost simultaneous	Id.
Brilliant flash and streak	. . .	Perseid . . .	Very low down; ↓ not seen, only flash and streak.	Id.

REAL PATHS OF LARGE METEORS DOUBLY OBSERVED

Date and Hour, G.M.T. (or Local Time). Size and General Appearance	Principal Places of Observation	Meteor's Real Course	
		Height and Locality of Beginning	Height and Locality of End
1858, Aug. 13, 6^h39^m p.m., $\frac{1}{3}$ moon's diameter. White, globular, with short bluish tail, and long white comet-like train pursuing it, but not persistent.	London, and Ryde, I. of Wight.	28 m. (?) over a point 20 m. seaward from the French coast at Dieppe (?)	12 m. (?) over a point midway between Brighton and Cherbourg.
1868, Sept. 5, 8^h 35^m p.m. (Berne time.)	Tours, Clermont Ferrand, Pic de Sancy, &c., France; Mayence; Zurich, Morges, Geneva; Bergamo; Germany, Italy, and Switzerland.	460 m. over a point a little W. of Sinope, Asia Minor. [Or (?) 250 m. over Belgrade.]	115 [or (?)70, or 100] m. over Ozaine, near Tours, France.
1873, Dec. 24 (7^h 39^m p.m. W.M.T.) Conical nucleus, brighter than full moon; yellow, with short tail of red and blue sparks. Burst (?) with loud detonation; left no streak.	Washington, and neighbouring towns in Virginia and Maryland; and at Richmond, Newark, Danbury, &c., in the United States.	About 90 m. over a point near Newcastle in the northern part of Delaware State, 30 m. S.W. from Philadelphia.	10 or 20 (?) m. over point near Fairfax Co., Virg., 30 or 60 (?) m. W.S.W. from Washington. Distance of the track from Washington by the sound-interval there, 31 m.
1877, Oct. 8, 12^h p.m. midnight. Bright fireball with long streak.	Bristol, Antwerp, and near Mezières, France.	80 m. over a point 15 m. W. of Allemaar, Holland.	35 m. over a point 60 m. W. of the same town.
1877, Dec. 9, 8^h 12^m p.m. A fine meteor = Jupiter, with long course and streak, 'mauve'-purple and green colours.	Royal Observatory, Greenwich, London, Bromley, and Writtle (Chelmsford). Three or four good observations, compared together by Major Tupman.	55 m. over Stoke Ferry, Norfolk.	36 m. over Stratford-on-Avon.
1878, April 2, 7^h 54^m p.m. Detonating fireball; $\frac{1}{2}$ moon's diameter; red; slow, halting motion; burst into fragments.	Blackheath, Birmingham, and Leicester. Calculated path by Major Tupman and Professor Herschel.	60 m. over a point 10 m. S. from Leicester.	15 m. (end-height very well determined) over a point 5 m. W. from Coventry, 35 m. (agreeing with the time-interval of the sound) from Leicester.
1878, Aug. 11 (about 10^h 10^m p.m.) $\frac{1}{3}$ diameter of, and outshone full moon; greenish; burst into three red fragments, and detonated.	Bloomington, Indiana; Virginia and Pennsylvania. Notice and calculation of the meteor's path by Professor Kirkwood.	About 77 m. over the northern part of Western Virginia (300 m. due E. from Bloomington; alt. 10°.)	15 or 20 m. (?) over Crawford County, Pa.; distance (by interval of the sound) W. of Titusville in that county, 25 m.

PRINCIPALLY IN THE YEARS 1878–1879.

Distances in British Statute Miles 'm.'		
Length of Path and Velocity	Observed Radiant Point α δ	Nearest known Radiant Point, and Remarks α δ
75 m. (?) in 2, or 4½ secs. Velocity, 23 miles p. sec.; not very certain. Parabolic speed 25 m. p. sec.	335° + 5° (± 5°); near θ Pegasi. A rough approximation.	337° − 6°, July 5–Oct. 31; Greg, 109, 137; 'Aquariads.' Many observed radiants near this place in August.
1780 [or (?) 1200] m. in 17 or (average) 42 secs. Average velocity 43 [or (?) 28½] m. p. sec. Parabolic speed 26 m. p. sec.	14° − 2°; near m (Bode) Ceti.	No previously observed radiant in September near this place.
Not definitely assignable; but probably about 120 m. in 3 to 5 secs. [The parabolic speed is 35 and the observed speed probably about 30 m. p. sec.]	30° N. of E.; alt. 25° by the mapped track. [Or at 115° + 38°, near π, α Geminorum; but about 113° (± 3°); + 32° (± 6°) is admissible from the observations].	[108° + 36°, Dec. 31, 1872, Dec. 27, 1876 (a); a radiant, near Castor]. Account of the meteor (by a Committee of the Society) in the 'Bulletins of the Philosophical Society of Washington,' vol. ii. pp. 139–161, with a map of the fireball's track.
63 m. in 4 secs.; 16 m. p. sec. Parabolic speed 40½ m. p. sec.	77° + 34°; at 16 Aurigæ.	Radiant-point of five other meteors on the same evening, W. F. Denning, at 77° + 31°.
100 m. in 3 secs., by two estimates of the duration; velocity 33 m. p. sec. (Parabolic speed 35 m. p. sec.)	112 + 27; between β and ι Geminorum. All the observed paths conform to it very nearly.	108° + 28°, Dec. 9, 1877; Corder. A sharply marked radiant of streak-leaving meteors (of which this was one) apparently not 'Geminids,' with long courses; not visible with the true Geminids, at 107° + 35°, on the 10th.
50 m. (beginning and length of path not very certain) in 3 or 4 secs. (Agrees with the parabolic speed of 13 m. p. sec.)	117° + 49° (± 3°); near χ Ursæ Majoris.	180° + 49°, April 1–15, Heis M_7. A principal radiant of the April 'Ursids;' whose streams are all nearly antiapical.
About 170 or 180 m. in 'two seconds.' (An 'uncertain' estimation; motion swift and apparently hyperbolic.)	292° − 31°, about (or from altitude about 17°, due south ?)	'The 'Analyst,' U.S. Journal of Mathematics, vol. v. p. 178; Iowa, 1878. The observations are scanty, but difficult to reconcile with a parabolic speed of 20 (*circa*) m. p. sec.

REAL PATHS OF LARGE METEORS DOUBLY OBSERVED,

Date and Hour, G.M.T. (or Local Time). Size and General Appearance	Principal Places of Observation	Meteor's Real Course	
		Height and Locality of Beginning	End
1878, Nov. 18, 9^h 50^m p.m. A fine slow-moving meteor, as bright as Jupiter or Venus.	Bristol and Writtle (Chelmsford). Real path calculated by Major Tupman and Professor Herschel.	70 or 80 m. over a point midway between Nantes and Angers.	45 or 50 m. over a point midway between Le Mans and Laval, France.
1878, Dec. 30 (about 6^h 57^m p.m.) As wide as moon's diameter, and several times as long (Wooster); greenish, and red at bursting, which it did into pieces, some distance before disappearing. No detonation heard.	Wooster, Ohio, and at Anderson, Ind., and Washington, Pennsylvania. (Notes and calculation of its path by Professor Kirkwood.)	72 m. over Columbiana County, Ohio.	17 or 18 m. above Tuscarawas County, Ohio (the explosion); height at final disappearance about 12 or 13 miles.
1879, Jan. 12, 7^h 25^m p.m. (Berlin time). Diameter of, and outshone the moon (Prague); globular with thin tail; disappeared suddenly. Violent shock and detonation heard in Prague, in $1\frac{1}{2}$ min. after disappearance.	Prague, Rakonitz, Petersdorf, Neucunnersdorf, and many other places in Bohemia. (Calculation, and accounts of the fireball's course, by Prof. von Niessl.)	40 m. over the Sudetengebirge (N.E. of Bohemia); but real beginning perhaps higher and earlier.	9 m. over Rakonitz; 25 m. W. from Prague (where distance by sound interval was about 18 m.).
1879, Jan. 12, 7^h 32^m p.m. (Berlin time). Similar appearance to the last meteor, but smaller, and not detonating.	Rakonitz, Neucunnersdorf, &c., in Bohemia; and Salzburg, Zittau, &c., in Tyrol and Saxony.	78 m. over a point near Pibram, Bohemia.	23 m. over Grosshain, near Dresden.
1879, Jan. 28, 2^h 28^m a.m. Immense fireball 4 × moon's diameter (Charlevoix, Michigan, where it burst overhead into fragments); fiery ring of sparks thrown off it, with earthquake like explosion, Traverse City, Mich.	Traverse City, Cheboygan, &c., Michigan; and Princeton, Wisconsin. Real path and notes of the meteor by Prof. Kirkwood.	Nearly 100 m. over a point in N. lat. 44° 25′, long. 9° W.	26 m. over Charlevoix, Michigan (probably lower, or continuing its flight somewhat further?)
1879, Feb. 22, 12^h 20^m a.m. Great fireball $\frac{1}{2}$ moon's diameter; white and green, then red, burst into fragments; cast an intense light; thunder-like report at Haverhill and Saffron Walden.	Haverhill, Saffron Walden, Bury St. Edmunds, Brentwood, and Godalming. (Real path by J. E. Clark and A. S. Herschel.)	50 m., or 75 m. over a point between Godstone and Guildford, Surrey.	5 or 6 m. over a point between Haverhill and Newmarket, Cambridgeshire.
1879, Feb. 24, 12^h 45^m a.m. Great fireball = full moon (York), white; long red or yellow tail seen at Brighton (at a distance); light like 'a summer day;' broke up or went out suddenly; violent report like an earthquake at York (and Stockton) in $1\frac{1}{2}$ min.	York, Whitby, Hull, and at distant places; Manchester, Liverpool, Birmingham, Brighton, Dundee, &c.	About 60 m. over a point 28 m. N.E. from Whitby (beginning, unobserved, still earlier).	6 or 7 m. over a point midway between Leeds and Selby.

PRINCIPALLY IN THE YEARS 1878–1879—*continued.*

Distances in British Statute Miles 'm.'		Nearest known Radiant Point, and Remarks
Length of Path and Velocity	Observed Radiant Point α δ	α δ
About 70 m. (The duration of the meteor's flight was not recorded.)	354° + 1°; at λ Piscium. [The radiant-point of Clausen's ☄ is in this constellation from mid-November to February.	350° + 2° Dec. 12, 1877; Denning. A radiant of very slow meteors, one of them a fireball. 4 + 4 December, Schmidt.
About 85 m. in about 2 secs. (first part of the flight). Velocity uncertain.	90° + 55° (± 10°); near δ Aurigæ. (Direction not very well determined.)	American 'Philosophical Society's Proceedings,' May 2, 1879; p. 241.
124 m. in 3–5 secs.; 6 estimates; average velocity 18 m. p. sec. (Parabolic speed 23 m. p. sec.)	133° + 19° (± 3°); near δ Cancri.	130° + 20°, Dec. 21–Jan. 5, 1876–7, Denning; ☄ 1680, Dec. 26, 132° + 21·5°; fireball, Jan. 19, 1877 (Ireland) 135·5° + 22° (von Niessl). The 'Cancrids' of January.—Vienna Acad. 'Sitzungsberichte,' vol. lxxix., May 8, 1879.
124 m. in '10 secs.' (and 60 m. in '5 secs.'); two estimates of duration; velocity about 12½ m. p. sec. (Parabolic speed 11 m. p. sec.)	52° − 10° (± 5°); near γ Eridani.	57° − 12°, Jan. 4–20, 1877; Dec. 2, 1877. And fireball of Jan. 7, 1877, England; 48° − 11° (von Niessl).—Ibid.
About 124 m. Duration not certainly estimated.	From alt. about 47° S.W. by S. (corresponding to 142° + 14°; between Leo and Cancer).	Apparently a Jan.–Feb. 'Cancrid;' 133° + 26°, Feb. 13, S.Z. 32; and ☄ 1833 ♋, Jan. 27, 135° + 25° (?). American 'Philosoph. Soc. Proceedings,' May 2, 1879, p. 243.
About 85 m. in 2–5 secs. Length of path and duration not exactly determined.	Between 135° and 145° = α, and 0° and + 10° = δ; near the head of Hydra.	141° − 2°, Jan. 1–March 16, Greg 15, 1876; 145° + 8°, Feb. 24, 1878; stationary, 4th mag. meteor; E. F. Sawyer.
About 87 m. in (?) 6 or 8 secs. Velocity about 14½ m. p. sec. (Parabolic speed about 18 m. p. sec.)	310° (± 15°), + 55° (± 10°) (alt. 32° N. 39° E.); provisionally given by the adopted real path; near χ Cephei.	No previously observed radiant at this place in February–March.

[*Continued from page* 91.]

the snow-clouds in the north-east for some seconds before the nucleus could be distinguished, exactly resembling the light of the moon rising behind the clouds in that direction.

It may therefore be concluded that the meteor passed about 40 miles over a point just south of Whitby and about 20 miles nearly over, but one or two miles north of York, to a point not more than six or eight miles above the earth, about midway between Leeds and Selby. The direction of this path is from 39° E. of N., alt. 32°, which at the time of the meteor's appearance corresponds to a celestial place of the computed radiant-point at 310° + 55°, near χ Cephei, a position, in February or March, of which no morning observations hitherto appear to have been obtained. The radiants of the comets 1854 IV. (Weiss, Feb. 13, 304° + 37°·5), and 1845 I. (Feb. 25, 309° + 30°·5), appear also to be too distant from this place to be compatible with the fireball observations.

Remarks on Double Observations of Large Meteors recorded in the Supplementary List.

1858, August 13, $6^h\ 39^m$ p.m. Fireball over the English Channel.—According to the observation of Mr. Pope Hennessey in London (these Reports, vol. for 1858, p. 152), a fireball exactly similar to that described near Ryde passed in two seconds from S.S.E., alt. 25°, to S.S.W., alt. 12°. At Ryde it travelled in 3–5 seconds from about E.S.E., alt. 15°, to S.S.E., alt. 20°. The lines of bearing intersect for the commencement about 20 miles off the French coast at Dieppe, 95 miles from both Ryde and London; and for the end point about half-way between Cherbourg and Brighton, 95 miles from London and 35 miles from Ryde. Comparing together the altitudes and distances at which the first and last points respectively of the meteor's course were observed from the two places, it will be seen that there is no exact agreement, the altitudes at the commencement being 25° and 15° at the same distance, 95 miles, from London and Ryde, while those of the end point are 12° and 20°, instead of about 8° and 20°, corresponding to the distances of 95 and 35 miles from London and from Ryde. In order to remove the discrepancy, the altitudes at first appearance cannot be retained without an enormous rotation northwards of both of the lines of sight of the meteor's starting point. It is true that very small departures of the two end point bearings from their assigned directions, by removing the end point southwards, would bring the final altitudes into good agreement. But it seems more probable that both the altitudes (12° and 25°) at London are as usual a little overrated, and if they are diminished by a third part, to 8° and 17°, their agreement with the altitudes observed at Ryde is then extremely close. The concluded heights are then 28 miles over the first and 12 miles over the last of the two points of intersection, and the length of path is 75 miles directed from an altitude of about 12° nearly due east. The correction which this provisional path seems to require most urgently is increase of height, especially at the end point. It would, in this case, be more nearly horizontal, and at the same time directed somewhat towards the south of west, or from somewhat north of east. The provisional radiant point on this supposition was about 5° north of east, alt. 5°; and of this origin of its flight, as a fairly probable direction, the corresponding celestial place

has been adopted in the table. The uncertainty of the meteor's real height and distance scarcely allows its real velocity (75 miles in 2 or $4\frac{1}{2}$ seconds) to be very confidently derived from the observed durations. The parabolic speed for the adopted radiant-point is 25 miles per second.

1877, October 8–9, midnight. Fireball in Holland.—Two observations of this fireball besides that mapped by Mr. Denning (these Reports, vol. for 1878, p. 282) were obtained, at Antwerp, and near Mezières, on the French frontier of Belgium. Although of the vaguest description, they yet confirm each other and support Mr. Denning's conjecture of the meteor's radiant point. Adopting this as quite certainly established, the meteor's real path may be pretty surely determined from the rough account of its apparent course at Antwerp. It appears to have been from 80 miles above a point of the German Ocean 15 miles due west of Allemaar to 35 miles above the sea 60 miles due west of the same town in Holland. The real length of path, 63 miles, performed in four seconds, gives a velocity relative to the earth of nearly 16 miles per second. The parabolic speed for the meteor's adopted radiant-points at 77° + 34° is 40·5 miles per second.

1877, October 14, 6^h 15–20^m and 6^h 55^m p.m. (Paris time). A very brilliant fireball (? two distinct ones) over Rouen and the mouth of the Seine, France.—No time of appearance was recorded by one observer, Mons. Martin, in Paris, who described the fireball as proceeding 'from near Ursa Major towards the left,' and as this is opposed to another description in Paris, that it fell almost vertically, a little inclined from left to right, and is only imperfectly corroborated by a third statement there, that the nearly vertical descent (in the west) was 'a little inclined from N.W. towards S.E.' (? S.W.), it is just possible that two other observations near Rouen, and at Neuilly Enthelle, in Oise, which give the time of appearance 6^h 20^m and 6^h 15^m, instead of 6^h 55^m, may relate to another perfectly similar and very similarly situated meteor to the later one, of which this discordant account in Paris may have been an additional description. But the celestial positions of the later meteor's path at '7 p.m.,' given by the observer in the Department of La Manche (which were indeed only gathered from descriptions), are also quite irreconcileable with the delineation of the meteor's course by the stars at Clermont Ferrand, although in conjunction with all the other statements they also agree in defining the radiant point's position as very near the zenith. The whole of the very conflicting particulars of the recorded paths and times of appearance of the meteor may therefore perhaps relate really to the descent of only a single great fireball near the mouth of the Seine a few minutes before 7 o'clock (Paris time) on the evening of October 8. The stars between Cygnus and Cepheus were in the zenith at that hour, and the meteor was without doubt directed from one of the northernmost of the Lacertid group of radiants in Lacerta and Cepheus, which are thickly clustered in and about the latter constellation in October. No sound of a detonation appears to have been distinguished, although the fireball burst 'like a bombshell' at the end of its course into many brilliant pieces; and it left a streak visible for a few seconds only on its course.

L. Gruber's Radiant Points for November 1–18,

Derived from 2,450 Shooting Stars ('British Association Report,' 1878, page 346), compared with other observations.

L. Gruber, 1877					Other observers			
No. in List	Duration of Shower November	Max. November	Position of Radiant α	δ	Position of Radiant α	δ	Duration or Dates of Max.	Observer	Notes
			°	°	°	°			
I.	1–18	13·0	148	+19	149	+23	November 13–15	G. and H. (171) .	*Leonids.* Comet I. 1866.
					140	+23	October . .	Schmidt . .	
(I.)	—	12	140·5	+21					(I) Double radiant seen by Gruber in 1871.
			149·5	+12	150	+13	October 11, 1869	Tupman (85) .	This centre is precisely at α Leonis.
II.	1–18	14·5	57	+30·5	60	+20	Oct. 21–Nov. 30 .	Greg (156) . .	Taurids I. Gruber's position is too far N. and very probably confused with showers near ε Persei 62°+37°, ε Arietis 43°+22°, and η Tauri 56°+23°.
		6	55	+19	62	+21	Oct. 12–Dec. 6	(41)	
			T. 52 ↓s		56	+24	November 1–13	Denning, 1878 (54)	
					62	+37	Oct. 12–Nov. 12	(49)	
III.	4–14	13·5	111	+59·5	110	+61	November 1–6 .	Denning (55) .	From Zezioli's observations.
IV.	1–18	13·5	62	+53	59	+53	November 15–27	Heis (A_{15}) . .	Ten ↓s at λ Persei.
					61	+48	Oct. 28–Nov. 13 .	Denning (45) 1878 (123) 1877	Forty-nine ↓s observed and deduced from various catalogues.
V.	9–12	11	70	+19·5	70	+20	November 10, 1868	S. and Z. (164) .	Gruber 75°+24°, October 20–21. Distinct shower from Taurids I.
VI.	2–14	10	103	+3	101	+7	November 7, 1869	Tupman (82) .	An active and well-defined shower in 1869, = Greg (153) 107°+7°, Oct. 8–Nov. 15.
					101	± 0	October 16, 1869	Tupman (87) .	
					100	+1	October 19, 1877	Denning (132) .	
VII.	1–18	18	135	+52	133	+48	November 1–15 .	Denning, 1878 (57)	Twenty-six ↓s = Greg (141). Seen also by D. Oct. 15–16, 1877.
VIII.	9–13	13	100	+41	98	+44	Oct. 12–Nov. 13 .	Denning, 1878 (38) 1877 (97)	Active shower, 8° E. of β Aurigæ. *Lyncids.*
IX.	3–12	6	125	+5	124½	+4½	November 7, 1869	Tupman (98) .	Accurate. Sharply defined (T).
X.	7–10	8	10	+39	6	+34	November 12, 1868	S. and Z. (168) .	A rich well-defined shower (= Greg's 103, Andromedes I. 7°+33°) is visible from this point in July–August.
					8	+35	Oct. 2–Nov. 13 .	Denning, 1877 (125)	
					9	+37	Oct. 29–Nov. 13 .	D. S. (1872) .	
XI.	11–13	12	316	+71	—		—	—	A new shower.
XII.	—	3	53	−14	54	−14	October 5–6, 1869	Tupman (78) .	= Greg's 164, 197, 138. More observations required of this apparently diffuse radiant.
			40	−25	57	−9	November 6, 1869	Tupman (96) .	
					40	−30	October . .	Schmidt . .	

It is singular that the large number of meteors projected by Dr. Gruber gave no decided indications of the *Cancrids* I. II. and III. 132°+21°, 120°+15°, and 132°+31°; or of the *Arietids*, 43°+22°, Oct. 31–Nov. 4; *Muscids* 42°+31°, and the many other showers visible at this epoch in Ursa, Camelopardus, &c.

Meteor Showers observed by W. F. Denning, July 21—August 10, 1878.

Total number of meteors seen, 621, in 34 hours' watching.

Duration	Radiant	↓s	—
July 31—August 1 . .	332+50	14	Lacertids. Short swift meteors.
July 27–31 . . .	341−13	54	Slowish long meteors. No streaks. Max.
July 21—August 1 . .	32+53	63	Swift short meteors. Streaks. Max. July 31.
July 31—August 1 . .	12+70	16	Not swift, faint. No streaks.
July 31—August 1 . .	321+31	10	Very slow. Max. August 1.
August 1–2 . . .	291+70	14	Swift short meteors. No streaks. *Draconids.*
July 25–31 . . .	6+37	18	Swift streak-leaving meteors. } *Andromedes.*
August 10 . . .	6+37	5	Swift meteors. } *Andromedes.*
July 29—August 2 . .	333+9	10	Very slow meteors.
July 21—August 1 . .	11+47 / 12+52	26	Very swift meteors. } Two showers close together? Swift. Streaks. } Two showers close together?
July 25–26 . . .	332+37	11	Bright slow meteors. Long paths.
July 26—August 1 . .	28+36	12	Very swift meteors. Streaks.
July 26–31 . . .	43+58	8	Swift meteors. Streaks. *Perseids.*
August 7–10 . . .	42½+54	106	Meteors very swift with streaks.
August 7–10 . . .	44+59	106	*Perseids.* A double radiant.
July 31—August 1 . .	6+11	9	Very swift meteors. Streaks.
July 29—August 1 . .	23+41	7	Swift meteors. Streaks.
July 26–31 . . .	333+18	8	Swift faint meteors.
July 27–31 . . .	332+27	8	Very swift and faint.
July 26–27 . . .	354+42	7	Slowish faint meteors.
July 28	305−15	5	Very slow meteors.
July 31—August 7 . .	3+27	7	Bright slow meteors.
July 30–31 . . .	96+72	5	Slow meteors. *Camelids.*
July 27–31 . . .	28+28	7	Swift, not quite certain.
August 1–10 . . .	47+25	6	Very swift long meteors. Streaks.
July 20–28 . . .	18+59	8	Swift meteors. Streaks.
July 21	234+48	3	Very bright slow meteors.
July 31—August 1 . .	65+60	7	Small slow meteors.
July 21–31 . . .	50+75	5	Short swift meteors. No streaks.
July 27 Slightly seen but both probably good radiants	284+44	2	Bright slow meteors.
July 28 Slightly seen but both probably good radiants	33−20	2	Very bright, swift, long-pathed meteors with streaks. Seen just before daylight.
July 31	22+13	4	Swift streaky meteors.
July 30–31 . . .	31+18	4	Swift meteors with streaks.
July 31—August 2 . .	331+62	5	Slowish faint meteors.
July 30–31 . . .	49+31	3	Swift meteors leaving streaks.

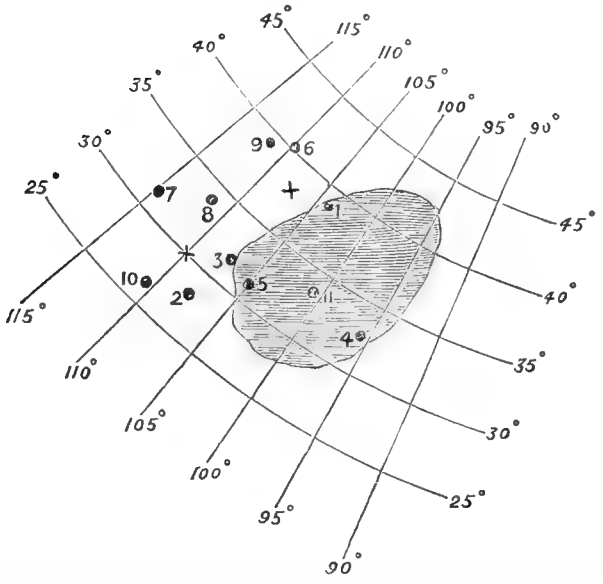
Shower centres also strongly suspected at 33°+21°, 134°+78°, 76°+54°, 20°+8°, 58°+47°, 316°+50°, and 41°+31°.

The above radiants may nearly all be relied on as exactly determined.

A List of observed Radiants of the 'Geminids.' By R. P. Greg.

No.	Ra. Dec.	Observers and Mems.—'Geminids,' December 9–14
	° °	
1	104 + 37	R. P. Greg, Dec. 10–11, 1877. Paths short, quick, not trained.
2	108 + 28	Corder, Dec. 9–12, 1877. Paths long, slower, trained.
3	107 + 33	Denning and Corder, Dec. 10–14, 1876 and 1877. (Three different results, almost identical.)
4	95 + 33	Dr. Heis, Dec. 8–11. (New Catalogue of 1876.)
5	105 + 32	R. P. Greg. General Catalogue (average) 1876.
6	110 + 40	Major Tupman, Dec. 12, 1870.
7	115 + 33	Tisserand. Toulouse Observatory, Dec. 11, 1876.
8	112 + 34	Mr. Wood, 1860.
9	112 + 39	Dr. Heis, Dec. 1–15. (M_9, Old Catalogue of 1867. Incorrect position ?)
10	111 + 27	Dr. Schmidt, Dec. 10–21. (Catalogue.)
11	100 + 33	Greg and Herschel, 1867. British Association Catalogue and Atlas. (Schiaparelli and Zezioli's *Caret.*)
	107 + 33½	General average position of *Geminid* Radiant. N.B.—Gruey thinks it a multiple radiant, so does Mr. Denning.

Radiants of Geminids.



Two different showers, one probably at 107° + 37°, and the second at 110° + 30°, with slower meteors and longer paths, and with more distinct streaks than the first one.

Appendix by Dr. Flight.

The Butcher Meteoric Irons of Cohakuila.[1]

Dr. L. Smith publishes a further paper on the new mineral occurring in the irons, to which mineral he has given the name of *Daubréelite*. It possesses the following composition:—

	Calculated.	Found.
Sulphur	44·29	43·26
Chromium	36·33	36·38
Iron	19·38	20·36
	100·00	100·00

It is a sulphide corresponding in atomic constituents to the well-known oxide, chromite (FeO,CrO_3), daubréelite being FeS,CrS_3, sulphur replacing the oxygen. The calculation of the composition is based upon the sulphur found in the analyses. The finer powder obtained by cutting sections of the irons are treated with a magnet to remove the nickel-iron; that remaining consists of torilite and daubréelite. This is then digested with strong hydrochloric acid several times; all the troilite dissolves readily, and the residue consists of the new sulphide. 'It consists of shining black fragments, more or less scaly in structure, not altogether unlike fine particles of molybdenite.' The fracture is uneven, except in one direction, where there appears to be a cleavage. It is brittle and easily pulverised, the fine particles retaining their brilliancy. It is not magnetic, and but slightly altered before the blow-pipe. It is not acted upon in the slightest degree by hydrochloric acid, either cold or hot, but dissolves slowly and completely in nitric acid when warmed with it. The specific gravity is 5·01.

Other meteoric irons, such as those from Toluco, Mexico, and Sevier Co., Tennessee, contain this mineral.

The Ovifak Irons.—Found 1870.[2]

The Academy of Sciences of Paris appointed a commission to report on a paper by Dr. Lawrence Smith on the supposed native iron of Greenland, and their report has recently been presented by M. Daubrée. It is pointed out that the bodies which come from beyond our atmosphere, and which are called meteorites, present, as regards their mineralogical constitution, a most striking resemblance to certain terrestrial rocks. The important fact that masses derived from most widely separated regions of space should present such resemblances was pointed out by Nordenskjöld in 1870, when he discovered large masses of native iron at Ovifak, on the island of Disco, Greenland. The first thought which suggested itself to him was that they were of meteoric origin. In order to explain the fact that these masses were fused into the basalt, he assumed that they had fallen into it while it was still liquid. Many adopted this view, and, among others, Nauckhoff and Tschermak. Steenstrup, on the other hand, after visiting the locality twice, came to the conclusion that they were masses of native iron, and that they had the

[1] *Amer. Jour. Sc.*, 1878, vol. xvi., p. 270.
[2] *Compt. Rend.*, vol. lxxxvii., p. 911.

same terrestrial origin as the basalt itself. Not far from Ovifak, in the Waigatstrasse, Steenstrup found evidence which supported this theory: in the basalt of Igdlokungoak he hit upon a mass of metalliferous magnetic pyrites weighing about 28,000 kilog., and again, in the basalt of Aussuk, small grains of native iron. The graphite associated with this iron pointed to the probability that carbonaceous substances had reduced this metal; moreover, the rock enclosing the native iron contained the silicate of ferric hydrate which has received the name of Hisingerite. With these opposing views so plainly set forth, Dr. L. Smith has gone over the whole question, and comes to the same conclusion as Steenstrup, that the masses of metal are of terrestrial origin. He finds that in the dolerite of Aussuk, as well as that of Ovifak, which it closely resembles, metallic iron is found enclosed in labradorite; anorthite is likewise found in certain parts of the mass of the rock, and oligoclase also.

Iron has been obtained from seven localities in Greenland: from Sowallicke, Fiskenäs, Niakornak, Glück's Bay, Jacobstown, Ovifak, and Aussuk. The iron of Sowallicke and Niakornak is found by Dr. L. Smith to contain combined carbon, just as the Ovifak iron does: in fact, he states that all specimens of iron obtained from Greenland are similar in this respect, and differ from meteoric iron, which contains no combined carbon; moreover, these masses all contain cobalt in considerable quantity in relation to nickel. Dr. Smith next refers to the similar geological character of the area where the iron has been found, it being found only in the basalt region, which extends from 69° to 76°, where it disappears under a huge glacier. We shall probably never know how wide the extent is of this volcanic area which stretches far away north; that, however, which has been seen represents an area equal to one extending from Gibraltar to Brest. We know that the terrestrial rocks which present the closest resemblance to the meteoric rocks belong to the lowest beds of the earth. Some are eruptive rocks of a basic character, consisting of anorthite and augite, like certain lavas from Iceland; others are olivinous rocks, like lherzolite, to which the meteorites containing magnesia—those, in fact, of the ordinary type—belong. The gangue of olivinous rocks accompanying the platinum of the Urals, and the presence of nickel in the native iron combined with the platinum, have confirmed these relations, which are of interest alike for the geologist and the astronomer. It was expected that among the aluminous and magnesian rocks some might be found in which iron should begin to make its appearance, and this gap has now been filled. In the Greenland beds layers of lignite are found associated with the basalt, and this may have furnished the material which has reduced the iron to the metallic state.

The Siderolite of Rittersgrün.—Found 1833.[1]

The examination by Dr. Clemens Winkler of the siderolite of Rittersgrün, Saxony, shows it to accord closely in composition with the siderolite of Breitenbach in Bohemia, examined some years since (1871) in the Laboratory of the Mineral Department of the British Museum; and to strengthen the view expressed at the time that these bodies, as well as the meteorite of Steinbach im Erzgebirge were probably members of

[1] *Nova Acta der K. Leop. Carol., Deut. Akad. der Naturforscher*, xl. Nr. 8, 333. Halle, 1878.

the same fall, possibly of the 'Eisenregen' reported on by Sarctorius (died 1609) as having fallen 'im Meissnischen' at Whitsuntide, 1164.

The Rittersgrün meteorite was found in 1833 by a workman employed in clearing the forest, and offered for sale as old iron to the smith, but without success; but in 1861 it came to the notice of the lamented Professor Breithaupt, and was secured for the mineral collection of the Berg-Akademie, of Freiburg. Its mean diameter is 0·43 mètre, and its weight 86·5 kilogrammes. It has recently been sawn through in Vienna, a troublesome and costly labour extending over two months. An excellent chromo-lithograph of the surface thus exposed was prepared by Professor Weisbach, in 1876, and published with a few notes.

The meshwork of nickel-iron of the siderolite encloses the following minerals: troilite, asmanite, bronzite, and chromite; the metallic portion constitutes about 51·06 per cent., and the non-metallic ingredients about 48·94 per cent. of the stone. The nickel-iron contains :—

Fe	Ni	Co	Ca	P	S	Si	C	Asmanite.	
89·990	9·740	0·230	0·035	0·150	0·011	0·066	Trace	0·056	= 100·278

which constituents may be arranged as follows :—

Nickel-iron Fe_9Ni	98·995
Iron-nickel phosphide $(FeNi)_4P$	0·293
Iron phosphide Fe_2P	0·539
Iron silicide Fe_2Si	0·330
Iron sulphide FeS	0·030
Iron carbide	Trace
Copper	0·035
Asmanite	0·056
	100·278

The iron sulphide, regarded as troilite, when in the form of pieces is not acted upon by the magnet, and when in the form of powder but feebly so. The ratios of iron to sulphur in troilite or iron monosulphite, and in magnetic pyrites, differ in so small a degree that the analytical results do not always put the question at rest. It is moreover a question whether the meteoric sulphide, associated as it is with nickel-iron, does not actually contain some of the metal as an ingredient. The numbers obtained in these analyses are as follows :—

	Calculated	Found		
		I.	II.	III.
Iron	63·63	65·87	63·58	63·00
Nickel	—	1·40	—	1·02
Sulphur	36·37	34·27	36·42	35·27
Silicic acid	—	—	—	0·67
	100·00	101·54	100·00	99·96

The asmanite appears to have the density of 2·274–2·278, and the following composition :—

SiO^2	Fe_2O_3	CaO and MgO.	Loss on ignition.		
95·77[1]	3·16	Trace	1·07	=	100·00
97·84	1·65	„	1·01	=	100·50

As regards the crystalline form of this mineral, Weisbach considers that the recent researches of Schuster and of Von Lasaulx, have placed almost beyond any doubt the identity of tridymite and asmanite. It occurred to the author that the relative solubility of tridymite and asmanite

[1] By difference.

in potash solution should be determined, and in as nearly parallel experiments as it was possible to devise, it was found that of tridymite from Siebenbürgen 49·63 parts, and of asmanite from Rittersgrün 43·88 parts were dissolved.

The bronzite, the most prominent of the non-metallic minerals, has been obtained in a pure form with comparative ease. It is but slightly affected by the blowpipe, and is not acted upon by acids with the exception of hydrogen fluoride. Its specific gravity is 3·310. It possesses the following composition :—

	I.	II.	III.
Silicic acid	57·27	56·56	56·56
Alumina	2·28	2·05	2·04
Iron protoxide	10·99	10·74	10·09
Manganese protoxide	0·41	0·42	0·55
Magnesia	24·78	25·13	25·59
Lime	1·77	2·52	1·66
Soda	not determined	1·43	1·43
Chromite	0·94	0·98	0·98
	98·44	99·83	98·90

No trace of olivine was met with in this material.

Heated *in vacuo* the substance of the meteorite lost 0·23 per cent. of the weight, and the gas evolved took fire, but was so small in quantity that it could not be further examined. The meteorite possesses the 'crust of fusion' in a fully developed form; it is of about the same thickness as a sheet of paper, and close under it are found the mixture of the minerals troilite, asmanite, and bronzite, of an unaltered light brown colour, although they turn deep black when raised to a temperature slightly above that at which lead melts. The author's pages conclude with some considerations on the probable temperatures of meteorites in their passage through our atmosphere.

Meteorite from Tieschitz, in Moldavia, July 15, 1878. 1.45 *p.m.*[1]

A stone fell at this date with the usual accompanying noise within 100 paces of some people whose attention was directed by a child four years of age to a small dark cloud, from which a peculiar and increasing noise proceeded. This cloud was suddenly seen to become incandescent, but in no very high degree, and the noise became still more intense when a body was seen to fall from the cloud. The stone was warm when found. The noise was heard about the neighbourhood 2 miles around. The stone was secured and sent on the 19th to the Museum of the Technical High School, of Brünn. The meteor appears to have passed over Daubrawic and Sloup, and the path to have been directed from azimuth 108, altitude 40°, or from an apparent radiant in R.A. 68°, N. declination 40°.

One stone only was found, and all search for other specimens of the fall were in vain. The stone weighs 27·5 kilogrammes, and has the form of an irregular pyramid with an almost square base.

The entire surface is covered with a black crust, in places of about the thickness of that covering the stones which fell at Pultusk; on the large convex side, which is called the 'breast-side,' it is much thinner, and exhibits a radiated character. On the back it is thicker and rougher,

[1] *Denkschrifte der math. Naturwissenschaften-Classe, Akad. der Wissenschaften.* Wien. xxxix. November 21, 1878.

and without a trace of the radiated structure. The 'breast-side' is free from all great depressions, while the others show them, due probably in part to the original form of the stone, partly to the action of currents of air on the melting surface. The freshly broken surface of the stone is dull ash-grey in hue, darker than the Pultusk stones, the texture finer and more sharply marked than in the case of most of the chondrites. We see many small dull grey or dark-coloured chondra, and splinters and fragments of the same kind, many larger dull grey chondra, also white small chondra and white fragments, the latter far fewer than the former. Between them an ash-grey earthy matrix, and very few yellow metallic lustrous particles. Most of the dark chondra are less than 1 mm. in diameter, those which have a diameter of 1 mm. are fewer, and there are occasional chondra which exceed 1 mm. in size; the largest one had a diameter of 5 mm.

The microscopic examination of the action of this material displayed many curious features, and appears to confirm the views already expressed by Professor Tschermak regarding the probable influences which have taken part in the form which the chondra and other enclosures take.

Some chondra presented an appearance which has not hitherto been observed. They have round depressions, which point to a plasticity of the chondra during contact, as if the spherules which form the splintered fragments had acquired their form during the act of rubbing. Others again have projections of a rounded form, or an almost pointed end. These chondra are the result of volcanic eruptions or explosions.

Olivine.—Both in the matrix, and in many chondra, well-developed crystals of olivine were met with. They have the same crystalline form as the olivine in basalt. Many of the chondra consist of individual crystals. Many crystals have cavities enclosing black angular grains, or a black impregnation of the crust, or black slightly translucent spherules or enclosures of 'glass'; some exhibit a most distinct surface of the enclosed material.

Bronzite.—Barred and fibrous individuals of a brown colour are regarded as bronzite. Some of the barred chondra shown in the plate accompanying the paper of Makowsky and Tschermak are very perfectly developed and very curious. Some have a darker border, others a lighter rim. In these chondra also the enclosed material already referred to is met with.

Enstatite.—Many of the chondra of this mineral are distinguished by their marked foliated structure, and specimens of such are shown in the plates. The enclosed 'glass' is also found in them. Many spherules, and fragments of spherules, of a crystallised mixture of bronzite and olivine or of enstatite and olivine were noticed, none however of a crystallised mixture of bronzite and enstatite, and it appears therefore as if this meteoric tuff originated from two sorts of stony mixtures.

Augite.—A few small chondra with a compact pale-coloured crust have a texture and colour which differs from all the foregoing. The entire spherule is shown by polarised light to be one individual; the crust is almost colourless, the interior has a brownish-green hue. Their reaction with light points to their being augite.

Magnetic Pyrites and Nickel-iron.—Magnetic pyrites occur as grains enclosed in the other chondra and splinters of chondra, as well as free in the matrix. The nickel-iron is for the most part in the form of irregular particles with a hackly surface in the matrix. In some of the spherules

both magnetic pyrites and nickel-iron have a distinct concentric arrangement.

The stone of Tieschitz belongs to that division of the chondritic meteorites which Tschermak some years since classified as remarkable for 'many brown finely fibrous chondra.' The specific gravity of the stone is 3·59. It contains about 85·0 per cent. of non-metallic minerals. No trace of any mineral resembling a felspar could be detected. The percentage composition of the stone was as follows :—

	Olivine	Bronzite and Enstatite	Augite	Magnetic Pyrites	Nickel-iron	Totals — Calculated	Totals — Analysis
SiO_2 . .	13·99	18·84	7·90	—	—	40·73	40·23
Se_2O_3 . .	—	—	2·09	—	—	2·09	1·93
Fe_1O . .	13·86	5·47	0·73	—	—	20·06	19·80
MgO . .	10·94	9·53	0·61	—	—	21·08	20·55
CaO . .	—	—	1·42	—	—	1·42	1·54
Na_2O . .	—	—	1·26	—	—	1·26	1·53
Fe . . .	—	—	—	2·46	7·97	10·43	10·26
Ni . . .	—	—	—	—	1·31	1·31	1·31
S . . .	—	—	—	1·62	—	1·62	1·65
	38·79	33·84	14·01	4·08	9·28	100·00	

or,

Olivine	38·79
Bronzite and enstatite	33·84
Augite	14·01
Magnetic pyrites	4·08
Nickel-iron	9·28
	100·00

Meteorite-fall at Esterville, Emmet County, Iowa, May 10, 1879, 5 *p.m.*[1]

A meteor exploded over this spot and was seen to fall in full daylight. One fragment weighing 500 lbs. fell on railroad land and was dug up from a depth of $14\frac{1}{2}$ feet in a stiff clay soil. Another portion weighing 170 lbs. fell at a distance two miles from the first. Many smaller pieces, of a few ounces or pounds weight, were scattered in the vicinity. The smaller mass fell upon a dry knoll and penetrated the earth vertically to a depth of $4\frac{1}{2}$ feet. The fall was accompanied by a noise described as a continuous roll of thunder accompanied by a crackling sound. The stone has been placed in the hands of Professor C. W. Hall, of the Minneapolis University, for complete examination. The preliminary examination points to the metallic portion consisting of an alloy of iron, nickel, and tin. Full half the mass consists of stony matter, which appears in dark-green crystalline masses imbedded in a light-grey matrix. When the whole is powdered a violent reaction ensues on the addition of hydrochloric acid, which is increased on boiling. The boiling acid appears to dissolve all but the grey matrix. Some of the crystalline masses are two inches in thickness and exhibit distinct monoclinic cleavage. Under the microscope, in thin sections, olivine and a triclinic felspar appear to be imbedded in a matrix of pyroxene. A

[1] *Amer. Jour. Sc.*, vol. xviii., p. 77.

polished specimen of the iron exhibits the Wiedmanstättian figures very finely.

A paper by Professor Gümbel, of Munich, entitled 'Die in Bayern gefundenen Steinmeteoriten' ('Sitzber. der K. Bayer. Akad. d. Wissenschaften, math.-phys. Cl., 1878, 1) treats of the meteorites of Mauerkirchen, Eichstadt, Massing, Schönenberg, and Krähenberg. He gives their history, their earlier analyses, and includes some new analyses, and a plate showing the microscopic sections as seen by the microscope.

Report of the Committee, consisting of Mr. David Gill, Professor G. Forbes, Mr. Howard Grubb, *and* Mr. C. H. Gimingham, (*with power to add to their number*), *appointed to consider the question of Improvements in Astronomical Clocks.*

This was only a preliminary Report, and at Mr. Gimingham's request its publication is delayed until next year.—[Ed.]

Report of the Committee, consisting of Professor G. Forbes (*Secretary*), Professor W. G. Adams, *and* Mr. W. E. Ayrton, *appointed for the purpose of improving an Instrument for detecting the presence of Fire-damp in Mines.*

This instrument is intended to measure the quantity of fire-damp in a coal mine. From the rough model shown by Professor George Forbes last year, the Committee have constructed two new instruments, which appear to them to answer their purpose quite well. The one is of a large size, and is worked by an electric battery, and is rather expensive. The other is small, portable, easily worked, and answers all the purposes for which it is required. Both instruments are founded upon the facts, that sound travels quicker in light gases than in dense ones, and that air which is contaminated with fire-damp is lighter than pure air. The velocity of sound in different qualities of air is compared by noting the lengths which must be given to a brass tube to cause it to resound to a tuning-fork. The length of tube is proportional to the velocity of sound. The instrument consists essentially of a tube with a tuning-fork at one end of it, and closed at the other end by a piston which can be moved in and out so as to lengthen or shorten the tube. The tuning-fork is caused to sound, and on moving the piston in and out the sound is heard to augment and diminish according to the position of the piston in the tube. The piston must be left in that position which gives the loudest sound. The length of the tube under these conditions measures the velocity of sound, and thence the percentage of fire-damp in the air.

In the large-sized instrument the tuning-fork is kept in vibration by an electric current which is made and broken in each vibration acting on an electromagnet so as to maintain the vibrations. The Committee have been unable to arrange the contacts in such a manner as to prevent the occurrence of a false note of considerable loudness. But in spite of this the ear can detect the true note and regulate the position of the

piston with even greater accuracy than when the tuning-fork is otherwise set in vibration. The reason is, that in other cases there is an irregularity in the loudness of the sound which alters slightly the velocity of the sound.

In the small-sized instrument the tuning-fork is set in vibration by means of a striker or rod, which is drawn by the hand between the prongs of the tuning-fork (which approach each other at their extremities). A little practice enables anyone to obtain in all cases the same loudness of sound. The Committee have added to this instrument a circular scale along which an index travels, being moved by a rack on the piston so arranged that it cannot give a false indication. By this means the length of tube can be read off easily, even in a bad light. In its present form the instrument is easy of use and convenient, and cannot easily get out of order. A thermometer is attached by means of which the small temperature correction can be applied. The percentage of fire-damp is read off directly upon the scale.

The accuracy of the instrument is such that the percentage of fire-damp can be determined with an error of considerably less than one per cent. The Committee would draw attention to experiments described in the 'Philosophical Magazine' for April 1879, which show that a difference of one part in 300 is not found between different observations of the length of tube which resounds to a given tuning-fork.

On August 25, 1879, the Committee were enabled to descend the Wharncliffe Silkstone Colliery by the kindness of the manager, Mr. George Walker, who accompanied them, with a few other gentlemen interested in the experiments. This pit is at a depth of 200 yards. Mr. Walker had kindly arranged to stop the ventilation of the pit at the end of the workings, so after proceeding a mile through the galleries they came to this spot, where they hoped to find a large amount of fire-damp. But only a slight quantity was to be found; the Davy lamp generally showing but a feeble blue cap, and the Forbes' indicator registering only small percentages. Disappointed here, they were taken by Mr. Walker to another working, where it was thought possible that there might be some gas. Here in a crevice in the roof a flow of gas was found forming a stratum of light gas. Here the instrument indicated quantities gradually increasing from 14 per cent. as the tube got filled with the air in the crevice, up to 28 per cent. But the small quantity of gas rendered this experiment unsatisfactory, and the Committee were then taken to a disused part of the mine where it was known that there was a blower. Here sufficient quantities were found, and the instrument registered gas with more readiness than the Davy lamp. But the greatest quantity registered was 6 per cent., or twelve times the smallest quantity which the indicator detects. The fact is that there is in the present form of the instrument a difficulty in filling the tube with the air of the place under examination. The Committee consider that it would be well to alter the instrument so as to obviate this difficulty; and they also recommend that experiments should be made to test whether the calculated percentages of fire-damp agree with actual experiment. They have also to report that the instrument was of a convenient form so as to be portable, and was very consistent in its indications, and they can assert that this instrument is capable of detecting and measuring fire-damp even in small quantities.

Report of the Committee, consisting of Mr. W. CHANDLER ROBERTS, *F.R.S.* (*Secretary*), Dr. C. R. ALDER WRIGHT, *and* Mr. A. P. LUFF, *appointed for the purpose of investigating the Chemistry of some of the lesser-known Alkaloids, especially Veratria and Bebeerine.*

SINCE last year investigations have been made on the alkaloids contained in *Veratrum album*, and *V. viride*, with the following general results. As the details of the experiments have already been communicated to the Chemical Society in two papers ('Journal of the Chemical Society,' 1879, i. pp. 405 and 421), it is unnecessary to quote them here.

Each kind of root was treated by the process described in last year's Report, viz., percolating with alcohol acidulated with tartaric acid, evaporating to a small bulk, treating with water to precipitate resin, filtering, alkalising with soda, and repeatedly shaking with a large bulk of ether, the ethereal solutions of alkaloids, &c., thus obtained being agitated with aqueous tartaric acid to remove the bases and then used over again. In each case a certain amount of flocculent alkaloidal matter was left undissolved by the ether, consisting mainly of an alkaloid analogous to jervine, but differing therefrom in certain respects, to which accordingly the name *Pseudojervine* is applied. The solutions of tartrates of alkaloids obtained were treated with soda and about an equal bulk of ether, whereby a large portion of the bases was dissolved in each case, but some left undissolved, especially with the *V. album* product; this insoluble matter contained pseudojervine, together with a little jervine, and in the case of the *V. album* product, a large quantity of an uncrystallisable base sparingly soluble in ether, to which the term *Veratralbine* is applied, as this body does not seem to be present in *V. viride* roots in any considerable proportion. The second ethereal solutions thus obtained deposited in each case crystals of jervine and a little of a new base to which the term *Rubijervine* is applied; the mother liquors of these crystals dried up to varnish-like masses, which were not identical in the two cases; the product from *V. album* roots consisted essentially of veratralbine, with a minute quantity of an alkaloid forming veratric acid on saponification with alcoholic potash; this base was the only alkaloid of the saponifiable class present in the roots; presumably it was the *veratrine* obtainable from *V. sabadilla* seeds, as described in last year's Report, inasmuch as the mixture of this base and veratralbine obtained was powerfully sternutatory, whilst the peculiar tendency to provoke sneezing was lost on treatment with alcoholic potash (neither jervine, pseudojervine, rubijervine, nor veratralbine produces sneezing). The product from the *V. viride* roots was even more powerfully sternutatory than that from the *V. album* roots; it consisted, however, almost wholly of *Cevadine* (the second crystallisable alkaloid obtainable from *V. sabadilla* seeds, as described in last year's Report), not more than traces of either veratralbine or veratrine being contained; on saponification it yielded about the theoretical quantity of cevadic acid (the *methyl-crotonic acid* of Frankland and Duppa, identical with the *tiglic acid* of Geuther).

The following table shows the approximate quantities of the different alkaloids contained in a kilogramme of each root examined :—

	V. album	V. viride
Jervine	1·3 grammes	0·2 grammes
Pseudojervine	0·4 „	0·15 „
Rubijervine	0·25 „	0·02 „
Veratralbine	2·2 „	Not more than traces
Veratrine	0·05 „	Trace ; less than 0·004
Cevadine	Apparently absent	0·43
Total	4·20	0·80

The *V. album* roots were consequently about five times as rich in total alkaloids as the *V. viride* roots.

The following are the chief characteristics and properties of the new alkaloids examined ; in many respects the statements of former observers concerning the alkaloids of these two kinds of roots appear to be erroneous, probably owing to the complete separation of jervine, &c., from the other substances now shown to be also present never having been previously effected.

Jervine.—When crystallised, $C_{26}\,H_{37}\,NO_3$, $2H_2O$: if the crystals separate from too hot or concentrated alcoholic liquors, somewhat less water is frequently present ; readily becomes anhydrous at 100° ; melts at 237°–239° (purest specimens—corrected). Forms an almost insoluble sulphate, and a very sparingly soluble hydrochloride and nitrate. The gold salt is $C_{26}\,H_{37}\,NO_3$, HCl, $AuCl_3$, H_2O, the water of crystallisation being lost only slowly at 100°. With strong sulphuric acid dissolves to a yellow fluid, quickly darkening to a greenish brown, which soon becomes a fine green by absorption of a little water from the air if in an open dish ; if in a test tube, becomes green by cautiously adding minute quantities of water. Not sternutatory : not saponifiable. The formula assigned in 1837 by Will to jervine (isolated by Simon), $C_{60}\,H_{45}\,N_2\,O_5$ (C=6, O=8), modified by Gerhardt and his followers to $C_{30}\,H_{46}\,N_2\,O_3$, is considerably incorrect, the error being apparently due to an imperfect nitrogen determination (by volume), and to the presence of pseudojervine in the substance examined.

Pseudojervine.—Crystallises anhydrous, $C_{29}\,H_{43}\,NO_7$. Externally resembles jervine closely : melts at 299° (corrected) : forms a sulphate crystallisable and soluble in water, especially when hot. Hydrochloride very sparingly soluble in water even when hot, provided no free hydrochloric acid is present. Gives with sulphuric acid exactly the same colour reaction as jervine. Not saponifiable : not sternutatory.

Rubijervine.—Crystallises anhydrous, $C_{26}\,H_{43}\,NO_2$: resembles jervine in appearance, and melts at nearly the same temperature (236° purest specimen—corrected). Sulphate and hydrochloride crystallisable and readily soluble in water, especially if warm. With strong sulphuric acid forms a yellow solution, becoming brownish yellow, brownish orange, brownish blood-red, and ultimately brownish purple by absorption of moisture : by cautious dilution with water the brownish blood-red fluid becomes successively crimson, purple, dark lavender, dark violet, light indigo. Not saponifiable ; not sternutatory.

Veratralbine.—Amorphous, approximately $C_{28}\,H_{43}\,NO_5$. No crystallisable salts obtained as yet. With sulphuric acid dissolves to a yellow fluid, becoming brownish orange and brownish blood-red, with a strong

green fluorescence; in this respect it closely resembles cevadine, which only differs in giving somewhat clearer tints, a crimson-magenta coloured fluid of a peculiarly beautiful and permanent shade being developed on absorption of a trace of moisture; veratrine (of Couerbe) gives precisely the same colours as cevadine, but the dark red solution formed before the crimson tint is developed by absorption of moisture does not exhibit any fluorescence. Veratralbine is not saponifiable, and is not sternutatory.

Seventh Report of the Committee, consisting of Professor PRESTWICH, Professor HUGHES, Professor W. BOYD DAWKINS, Professor L. C. MIALL, Rev. H. W. CROSSKEY, Messrs. W. PENGELLY, W. MOLYNEUX, D. MACKINTOSH, R. H. TIDDEMAN, J. E. LEE, *and* J. PLANT, *and* Dr. DEANE, *appointed for the purpose of recording the position, height above the sea, lithological characters, size and origin of the Erratic Blocks of England, Wales, and Ireland, reporting other matters of interest connected with the same, and taking measures for their preservation. Drawn up by the* Rev. H. W. CROSSKEY, *Secretary.*

DURING the past year several contributions of interest and importance have been received respecting the position and distribution of Erratic Blocks.

Mr. Townshend M. Hall, F.G.S., reports the finding of a boulder (May 1879) in cutting a drain in the village of Bickington, parish of Fremington, beneath the turnpike-road leading from Barnstaple to Bideford, at a point two miles W. by S. of Barnstaple. Its dimensions are $3 \times 2{\cdot}5 \times 2$ feet. It is rounded and smooth on the sides and under surfaces. The upper face is rough, having apparently been broken away in making the road. It is doubtful whether there are any ruts, groovings, or striations, the under surface having been only felt and not seen. It is composed of fine-grained granite, and there is no similar rock nearer than Lundy Island, 25 miles W.N.W. from the boulder, and Dartmoor, 25 miles S. by E. Its height above the sea is about 80 feet. It is not indicated on any map. The larger portion still lies buried under the road, one end having been broken away to make room for the drain. It is situated in a bed of high-level gravels, with red sand and clay, resting upon carboniferous grits and shales.

The occurrence of this boulder (Mr. Hall remarks) is of special importance in connection with the still larger one at Santon (described in the first Report of this Committee, British Association Reports, 1873, p. 193), from which it is distant $6\frac{1}{2}$ miles S.E. by E.

The Bickington drain was cut in places to a depth of $7\frac{1}{2}$ feet without reaching the bottom of the gravel bed. Amongst the larger pebbles associated with it, two of similar granite were found, well smoothed, and measuring 7×5 inches.

Worcestershire.—Erratic blocks have been found at remarkably high levels for the Midland district, of 750 feet, upon Frankley Hill. The writer of this Report examined them in company with Professor Bonney and Mr. W. Matthews.

In a cutting of the new Hales Owen Railway, passing through Frankley Hill, the following section has been exposed :—

Permian clay.
Sand of clay texture.
Yellowish sand.
Greyish sandy clay, with Bünter pebbles.
Clay, somewhat sandy.

The heights of these various beds are very irregular throughout the section, which is in itself about 60 feet in depth.

The Permian sandstone is exposed at one point in the section, and fragments of it are scattered through the sands and clays.

Erratic blocks are rare in the sands and clays of the cutting itself; one only, indeed, a greenstone, was noticed at the time of our visit, although doubtless they occasionally occur.

No part of this section can be called a boulder clay, if by boulder clay be meant either a clay formed beneath land ice, or a clay carried away by an iceberg and deposited over the sea-bottom as the berg melted or stranded.

The various sands and gravels present all the appearances of a 'wash' from older beds, effected during the depression and subsequent upheaval of the present land surface. They are neither compactly crowded with erratics, nor are any grooved and striated fragments of local rock heaped irregularly together. The way in which the pieces of native rock are scattered through the beds does not indicate any other force than that which would be exerted by the ordinary wash of the waters during the movements just mentioned. The presence of a few erratics shows that the wash must have taken place beneath the waters of a glacial sea over which icebergs floated.

These beds appear to have been formed in the earlier rather than the later part of the glacial epoch. In a field *on the summit of the section* a large number of erratics are to be seen which have been taken from a recent surface drain. These erratics constitute a group of allied rocks evidently from one district. Among those observed (undoubtedly, however, a large number must still be concealed beneath the soil) twenty were felsites, two were basalts, one was a piece of varied quartz, and another a Welsh diabase.

Professor T. G. Bonney makes the following remarks upon these boulders :—

'The basalts are very little if at all decomposed, such as might have come from one of the basalts of post-carboniferous but pre-triassic age at Rowley, Pouk Hill, or the Clee Hill. There is no reason, however, for assigning them to the first or second of these localities; with the third I am not familiar. The "greenstone" is remarkably like several that I have seen in Wales as, for example, in the vicinity of the northern end of Llyn Padarn, from which locality, however, it is not likely to have come. If examined microscopically it would doubtless be found to be composed of a triclinic felspar augite and possibly olivine with some chlorite. Thus it may be called a diabase. The felsites have a considerable semblance one to another. They are of a greyish colour, weathering to a paler tint. They present occasionally indications of fluidal structure and flow brecciation, some looking rather slaggy as if from the outer part of a flow, and I think they have been derived from this and not from an intrusive boss. I feel certain they are from Wales, and are of Lower

Silurian age, but whether from the interbedded volcanic rocks of the Llandeilo or the Bala series I am not sure. One would expect them to come from the Arenig district. I have seen nothing like them in the Lake District.'

Two of the felsites are of considerable size, the larger being $4 \times 4 \times 2$ feet.

Similar blocks may be traced almost to the summit of the hill. One felsitic block opposite the Yew Trees is $4{\cdot}5 \times 3 \times 2$ feet.

The height of these boulders above the sea is remarkable for the district, their highest level being about 750 feet. This fact indicates a corresponding depression of the land, since no Welsh glacier could have travelled over hill and down dale to this summit level. To render any such glacier work conceivable, the Welsh mountains must have stood at a height beyond any point for which there is the slightest evidence.

This group of boulders on the summit of Frankley Hill appears to have been dropped by an iceberg travelling from Wales, upon the top of the clays and sands exposed in the railway cutting, at a time when the land was depressed at least to the extent of at least 800 to 1,000 feet. In the clays and sands upon which the summit group of erratics rest, we must have beds belonging to an earlier date than the *close* of the glacial epoch, and the erratics in the cutting must be discriminated from those left at the higher level.

Staffordshire.—The following among the innumerable erratic blocks scattered over the central part of the midland district deserve a special record in addition to those described in previous Reports.

1. A boulder of felsite in the brickyard at the bottom of Oak Street, Wolverhampton.

This boulder is of an oblong form, and measures $11 \times 3 \times 3$ feet for a considerable portion of its length, although tapering in a somewhat irregular manner towards its ends. On the upper surface are rude and rough groovings running in all directions, and doubtless produced by the plough; but one of the sides exposed is flat and smooth, and is covered with parallel striæ, affording an extremely fine example of glacial action.

The clay by which it is surrounded contains many more or less rounded pieces of granite, as well as of felsite, flints, together with quartzite and other pebbles from the Bünter beds.

The large felsite ice-marked boulder described was probably *dropped upon* the clay in which it rests, this clay itself being composed of the material brought by one of the earlier icebergs and intermixed with material of more local origin by the currents prevalent during the movements of the sea-bottom at a later period.

In the immediate neighbourhood is a surface boulder of granite measuring $3 \times 3{\cdot}5 \times 2$ feet. The grouping of these surface boulders needs to be carefully observed, as distinguished from the accumulation of blocks of all kinds, in the sands and clays upon which they rest, or into the heart of which they have fallen.

2. An erratic block of slate, situated in a field near the Fox Inn, on the road to Trescott.

This block has split into two pieces, the larger piece measuring $11{\cdot}25 \times 3{\cdot}25 \times 3{\cdot}5$ feet, and the smaller $9{\cdot}25 \times 3 \times 3$ feet. It originally rested upon the surface, but some years ago it was buried, in order to utilize the land for agricultural purposes. An excavation was recently

made (at the instance of the Dudley and Midland Geological Society) that it might be examined.

This is the largest erratic block of slate that has yet been seen in the district, and it is associated with very numerous boulders of granite and felsite.

3. Mr. E. B. Marten has called attention to a boulder recently discovered by Mr. Beale in a watercourse running nearly due N. and S. near Moseley Hole, and the Wolverhampton, Willenhall, and Walsall turnpike-road, and an accommodation road across the collieries from the Osier Bed Furnaces and Slow Lane, to Bilston. It is in the line of the third 'h,' in the words 'Stow Heath Furnace,' and the letter 'P,' of 'The Plough' on the one-inch Ordnance Map, No. 62, S. W. Lichfield.

The boulder is composed of granite, and measures about 4·75 feet every way. Its weight is probably about three tons. Its shape is sub-angular, the angles being, with one exception, slightly rounded, but this exception is as sharp and clean as though the block had just been detached from its parent rock. The soil in which the boulder occurs is of a gravelly and sandy nature, containing some pebbles bearing the well-known indentations peculiar to, and characteristic of, the pebble beds of Bünter. Its height is 420 feet above the sea-level.

4. At Manor Green, half-a-mile S. of Walsall, in a field near the Old West Bromwich road, a block of felsite stands erect, like a pillar. It measures $4{\cdot}5 \times 4{\cdot}5 \times 2$ feet.

Mr. D. Mackintosh reports on the origin of the so-called 'greenstone'[1] boulders around the estuaries of the Mersey and the Dee (the occurrence of which has previously been recorded in these Reports by Mr. G. Morton, F.G.S.), to the following effect:

While tracing Criffel boulders southwards, he has observed 'greenstone' (or as they are locally called, 'whinstone') boulders and pebbles apparently on their way south, along with the granite on the west coast of Cumberland, N. of Whitehaven. Between the Scottish and Cumbrian coasts and the peninsula of Wirral (between the estuaries of the Mersey and the Dee) the course of these boulders is lost under the Irish Sea. The area around the Mersey estuaries in which the boulders are very much concentrated is intensely striated, and nearly all the striæ point divergently to the S. of Scotland, i.e. between N. 15° W. and N. 45° W.

On the most extensively glaciated rock surface (successively exposed and demolished by quarrying operations near St. James' Church, Birkenhead), the larger grooves point to between 25° and 30° W. of N.

A large 'greenstone' boulder has been found at Crosby, near Liverpool, resting on a perfectly flat glaciated rock-surface with striæ pointing N. 40° W.

Additional presumptions in favour of the Scottish derivation of these boulders may be found (1) in the fact that nearly all of these boulders consist of basic rocks similar to some at least found in the S. of Scotland; and (2) in the extent to which they are concentrated and almost entirely locally limited to the peninsula of Wirral and the neighbouring part of Lancashire. This last circumstance shows that they could not have come from widely different points of the compass, while it is as probable as the

[1] The word 'greenstone' is retained in the text because the boulders have frequently been described under this name. It is, however, inaccurate. Most of the boulders in question are dolorites or diorites.

nature of the subject will admit that there is no single locality from which they could have been derived excepting the S. of Scotland.

Many fresh 'greenstone' boulders have been lately exposed in the newest Bootle Dock excavation. The largest is $6 \times 4{\cdot}5 \times 3$ feet, and was found on the surface of the upper boulder clay. A very large proportion of the boulders are excessively flattened and regularly grooved. One has been removed to the inner end of the passage between the Liverpool Free Library and the Picton reading-room. Three feet in diameter of its surface are perfectly flattened and indented with deep parallel grooves like a work of art.

It is a remarkable fact that in the Bootle Dock excavations the 'greenstone' boulders are accompanied by very little Scotch granite; while on the shore of the Dee estuary between West Kirby and Parkgate similar boulders are associated with much Scotch granite. It is also remarkable (and equally difficult to explain) that whilst at Bootle the boulders are intensely glaciated on the shore of the Dee estuary, scarcely any of them show signs of ice-action.

The largest boulder on the shore of the Dee estuary is $6 \times 4 \times 3$ feet, and is apparently a diorite.

Mr. J. R. Dakyns favours the Committee with the following Report on the Shap Granite Boulders on the Yorkshire Coast:—

Shap Granite Boulders on the Yorkshire Coast.

I have examined this coast from Cloughton Wyke, 4 miles north of Scarborough, to the Talbot Hotel, 6 miles south of Hornsea, a distance of about 46 miles.

The boulders of Shap granite are not found indifferently on any part of the coast, but they occur plentifully at certain parts, and are entirely wanting along the rest of the coast.

Within the space examined they occur principally in four localities, as follows, beginning from the north: there are several, four at least, at Long Nab, on the north side of the Nab; one of these measures 8 cubic feet; there are also several, six or seven at least, at Cromer Point, also on the north side of the point.

South of Cromer Point there are none till you come nearly to Filey. There is one large one, measuring nearly $3 \times 2\frac{1}{2} \times 2$ feet, on the top of the cliff about a mile from Filey; this is at the third fence north of the notice 'No Road' near the Spa; it bears N. 15° E. from Filey Station. It is probably practically undisturbed, for the ground slopes inland from the cliff, and therefore if it has been turned up in ploughing and moved, it cannot have been moved far, for no one would take the trouble to cart a huge boulder far uphill. This is the only undisturbed boulder of Shap granite that I have seen on the land; all the others are on the shore, and have fallen out of the cliff above them. There are several on the shore along the north part of Filey Bay, but none along the south, nor are any more to be met with going south till one reaches Flamborough Head.

There are several on the shore between Flamborough Head and Flamborough South Landing. Some of these are large, one measuring 36 cubic feet.

South of this locality, the only one I have seen on the shore, is a small one rather more than a mile south of Bridlington Quay. But I do not doubt that they do occur farther south occasionally, because there is one built into a wall at Hornsea.

NOTE.—In the British Association Report for 1874, p. 196, the Hitching stone (Yorkshire) is described as an erratic block. Mr. Dakyns cannot think that this is correct, and writes the following note upon it:

'The stone is a block of millstone grit, standing on the escarpment of a bed of grit not dissimilar in character. I believe this stone to be a portion of this bed remaining in place, the immediately surrounding part having been denuded. The stone is standing, as it might have stood originally in its bed. It is angular, and bounded by joint surfaces just as it would be on the removal of the surrounding block.

'In brief, it has no single characteristic of a boulder about it. It is not rounded nor scratched, nor is it standing on end, nor in any such a way as to raise a suspicion of its having been moved. Nor is it of a different character from the rock on which it stands, and there are no other boulders connected with it; nor are there anywhere in that country any boulders that are not mere pigmies beside it; nor do I know of any boulders in the country saving such as are actually embedded in drift, and none of these are large.'

Fifteenth Report of the Committee, consisting of JOHN EVANS, *F.R.S.*, Sir JOHN LUBBOCK, *Bart., F.R.S.*, EDWARD VIVIAN, *M.A.*, GEORGE BUSK, *F.R.S.*, WILLIAM BOYD DAWKINS, *F.R.S.*, WILLIAM AYSHFORD SANFORD, *F.G.S.*, JOHN EDWARD LEE, *F.G.S.*, *and* WILLIAM PENGELLY, *F.R.S.* (*Reporter*), *appointed for the purpose of exploring Kent's Cavern, Devonshire.*

Your Committee, in this their Fifteenth Annual Report, on taking up the narrative of their researches at the point at which it was dropped in their Fourteenth Report, read during the meeting in Dublin in August, 1878 (see Report, British Association, 1878, pp. 124-129), beg to state that, during the twelve months which have since elapsed, the work has been continuously carried on in the same manner and under the same daily superintendence as heretofore, and that the workmen named last year—George Smerdon (foreman) and William Matthews—have continued to perform the manual labour throughout the year to the full satisfaction of the Superintendents.

Visitors.—The Superintendents have had the pleasure, as in previous years, of admitting and conducting numerous ladies and gentlemen into the Cavern, and have availed themselves of such opportunities of stating and explaining the principal discoveries made from time to time, as well as their palæontological and anthropological bearings. The following may be mentioned as amongst the visitors thus admitted:—The Princes Edward and George of Wales, with their tutor, the Rev. J. N. Dalton; the Revs. Canon Greenwell, Dr. Baron, P. Douglas, W. Downes, Dr. S. Haughton, E. Mansfield, Dr. Punshon, and W. S. Symonds; Captain Thomson, Dr. T. Barlow, Prof. A. H. Church, and Messrs. J. R. Barlow, A. Baron, W. H. Baron, J. S. Bartlett, C. Biggs, E. F. Boyd, F. C. Bury, W. Bracken, R. A. Clark, T. E. Cobb, H. Cooper, W. Cotterell, R. E.

Cunliffe, M. R. Currie, W. Curtis, G. Doe, G. Ferrand, E. Fox, F. W. Fox, S. Haughton (Ceylon), G. J. Hinde (Canada), B. C. Hobbs (Indiana, U.S.), C. S. Hockin, W. Jones, T. G. B. Lennard, W. Medlicott, W. Parker, A. C. Pass, A. Pengelly (Punjab), R. Perks, W. Perks, H. W. Reynolds, T. W. U. Robinson, E. W. Smithson, H. Rowe, W. Russell, J. W. Wilson, W. Wilson, and J. E. Wolfe.

In addition to visitors accompanied by a Superintendent, a large number have been admitted by the authorised guide, under clearly-defined and well-observed regulations.

Financial.—During the year the following contributions towards the funds for carrying on the work were handed to the Secretary:—Mr. Gerard Ferrand, 5*l.*; Rev. Canon Greenwell, M.A., F.R.S., F.S.A., 1*l.*; Mr. T. W. U. Robinson, F.G.S., 1*l.*

Living Animals still frequenting the Cavern.—As in previous years, the workmen have frequently seen rats in the innermost recesses of the Cavern, and during the twelve months eleven were taken in a gin placed on a rock at the remotest point of the 'Cave of Inscriptions,' fully 380 feet from open day. It may probably be presumed that they were attracted by the droppings of the workmen's candles.

The High Chamber.—When the Fourteenth Report was closed (July 31, 1878), the workmen were engaged in excavating the deposits in a branch of the Cavern termed the 'High Chamber,' into which they had then penetrated about thirty feet from its entrance, that is, its junction with the Cave of Inscriptions, out of which it opens (see Report, British Association, 1878, p. 128). This work was continued without intermission until its completion on January 9, 1879, when the High Chamber was found to extend in a north-westerly direction for a distance of about 53 feet, to vary in width from 5 to 10 feet, and in height from 14 feet at the outer to 8 feet at the inner end, the measurements being made for the width at the top of the mechanical deposit, and for the height from the roof to the bottom of the excavation, which, however, did not reach a limestone bottom.

At its inner or north-western end the High Chamber sends off two branches, one towards the north and the other towards the south. The northern branch was excavated for a distance of 12 feet, where, though the end was not reached, the work was abandoned, for the deposit—breccia, blocks of limestone, and crystalline stalagmite—reached the roof, and was so compact as to bar all further progress, except by the expenditure of a very large amount of time and money. This branch, which varied from 5 to 7 feet wide, may be regarded as a portion of the High Chamber. How far it extends, and whither it leads, are questions for speculation merely.

The exploration of the southern branch presented fewer difficulties, and was much more successful. This branch will be subsequently described under the name of the 'Swallow Gallery.'

The roof of the High Chamber throughout the outermost half of its length shows distinct traces of the long-continued action of running water, but beyond that distance it has an angular and less ancient aspect, due, no doubt, to the comparatively recent fall of the masses of limestone which occupied the floor, whilst at the inner end it was much shivered.

Indeed, the workmen had to dislodge one large mass of rock which appeared very insecure and threatened to fall.

The mechanical deposit found in the High Chamber was exclusively Breccia, the oldest the Cavern has yielded. It was covered with the crystalline, or most ancient, Stalagmite over a considerable area (see Report, British Association, 1878, p. 128), but elsewhere it lay immediately beneath the large masses of limestone already mentioned or was without covering of any kind. Its upper surface, ascending continuously from the entrance of the Chamber, reached near the inner end a level about 7 feet above that of the Breccia in the adjacent Cave of Inscriptions. From this point it rose at a comparatively steep gradient over a series of limestone terraces or steps, and beneath a well-defined sheet of Stalagmite, until it reached the roof, where the two deposits occupied and completely filled a 'swallow hole' in the north-western corner of the Chamber.

After the Fourteenth Report was drawn the High Chamber yielded forty-one 'finds,' of which sixteen were either lying on the surface without any covering or were within a foot of it; four were in the second foot-level below the surface; eight in the third foot-level; and thirteen in the fourth, the lowest excavated. Eight of the 'finds' consisted of artificial objects only, whilst the remaining thirty-three were almost exclusively relics of mammals, and included thirty teeth of bear and one of fox, together with a considerable number of bones and pieces of bone.

At least some of the objects lying on the surface had no claim whatever to antiquity. Thus, on September 23, 1878, there were found ('find' No. 7,214) on the exposed surface of the Breccia, where it contained an unusual amount of very fine sand, a large number of quill-like tubes of stalactite, and with them a portion of the stem of a clay tobacco-pipe. The whole, including the sand on which they lay, had the appearance of having been washed to the spot they occupied, probably during a period of protracted and heavy rains, when the drip from the roof would be unusually copious.

Again, on October 22, 1878, a one-bladed penknife ('find' 7,222) was met with on the unprotected surface of the Breccia, without any object of interest near it.

The presence of these recent articles is in no way surprising, and presents no chronological difficulty, as there was nothing to prevent an adventurous visitor from reaching the spots where they were found; and it cannot be doubted that some such person lost the penknife, and that a smoker threw away a portion of the tobacco-pipe he had unfortunately broken.

Many of the teeth of bear occupied jaws or portions of jaws. They were most prevalent in the lowest level; there being four specimens in the uppermost or first foot-level; five in the second; four in the third; and seventeen in the fourth or lowest. Though many of them were fine specimens, none call for detailed description or special remark. It may suffice to direct attention to the 'find' No. 7,245, met with on November 13, 1878, in the first foot-level, and consisting of an almost entire right lower jaw of Bear, a portion of a left lower jaw, also of Bear, and one bone. The right jaw contained the canine tooth only, and appears to have been crushed after its deposition. The fragment of left jaw was that of an immature animal, and contained one molar.

The artificial objects met with, in addition to the stem of tobacco-pipe

and the penknife, mentioned already, were flakes and chips of flint and chert, of which there were nine:—

No. 7,207, found, with one tooth of Bear, in the fourth foot-level, August 8, 1878.

No. 7,211, found, with one tooth of Bear and one bone, in the fourth foot-level, September 18, 1878.

No. 7,219, found, with one piece of bone, in the fourth foot-level, October 5, 1878.

No. 7,220, found alone, in the fourth foot-level, October 9, 1878.

No. 7,224, found alone, in the fourth foot-level, October 25, 1878.

No. 7,225, found alone, in the third foot-level, October 29, 1878.

No. 7,226, found alone, in the fourth foot-level, October 30, 1878.

No. 7,232, found alone, in the third foot-level, November 9, 1878.

No. 7,256, found alone, in the fourth foot-level, January 9, 1879.

Compared with the numerous fine implements found, from time to time, in other parts of the Cavern, none of the specimens in the foregoing list are in themselves of much importance or interest. They are all more or less porous, and adhere to the tongue when applied to it.

No. 7,211 measures 1·8 inch long and broad, and 0·4 inch in greatest thickness. Its inner face is slightly concave: whilst the outer, produced by the dislodgment of five flakes, is convex. Its margin, elsewhere rudely curvilineal, is on one side almost a chisel-like edge, but somewhat broken.

No. 7,224 is a leaf-shaped flake, bluntly pointed at one end, and obliquely truncated at the other. The inner face is saved by the 'bulb of percussion' from being quite flat; whilst the outer has a strong, nearly central, curvilineal ridge. There appear some indications on its edges of its having been used as a tool, and it has perhaps undergone a slight amount of rolling. It measures 3·1 inches long, 1·8 inch in greatest breadth, and 0·7 inch in greatest thickness.

No. 7,232 is rudely rhombohedral in form. The inner face is slightly concave, and has a 'bulb of percussion;' the outer is convex, and formed by the dislodgment of three flakes, leaving as many parallel longitudinal areas, the central one being broad compared with those on each side of it. This specimen may also perhaps have been slightly rolled.

Including those reported last year (Report, British Association, 1878, pp. 128–9) the 'finds' met with in the High Chamber amounted to ninety-four in number, and contained 119 teeth of Bear, one tooth of Horse, one of Fox, numerous bones and bone-fragments, one flint nodule tool, eleven flakes and chips of chert and flint, and one quartzite pebble.

Your Committee remarked last year that the flint specimens occurred in the third and fourth foot-levels only (*op. cit.*, p. 129). It will be seen from the list given above that this was also the fact with regard to the similar specimens found since. In short, of the twelve specimens of flint and chert found from first to last in the High Chamber, none occurred in the first or second foot-levels, four were met with in the third level, and eight in the fourth, or lowest foot-level, to which the excavation was carried.

The Swallow Gallery.—The branch thrown off towards the south from the inner end of the High Chamber, as stated above, has a total length of about 50 feet, and consists of two Reaches, the first extending southwards about 26 feet, where the Gallery turns sharply eastward, and

extends in that direction about 24 feet. The width varies from 10 to 2·5 feet; and the height, from 6 feet, at the entrance, to 8 feet at the inner end.

Judging from its roof, this Gallery was, during a long period, a tunnel completely filled with running water; and this is confirmed by the character of the walls, on which, however, indications of *corrosion*, subsequent to the *erosion*, are numerous and well-marked.

About 18 feet from the entrance of the first Reach, a considerable irregularly-cylindrical 'Swallow Hole' extends obliquely upwards into the roof, and is quite empty for a height of about 7 feet, above which it is completely filled with typical Breccia and Stalagmite. The Gallery takes its name from this hole.

The deposit occupying this gallery was everywhere the Breccia, having no continuous stalagmitic covering until within the innermost 10 feet, and even there its thickness was inconsiderable. The upper surface of the Breccia had a uniform fall, amounting to a total of 38 inches, from the outer to the inner end of the Gallery, where it plunged rapidly into, and completely filled, a tunnel; and, being mixed with large masses of limestone, the work in that direction was abandoned on May 24, 1879, the exploration of the Swallow Gallery having occupied about nineteen weeks.

This branch of the Cavern, the two Reaches included, presented fifty-eight 'finds,' of which thirty-three were on the surface of the Breccia or not more than a foot below it; fourteen were in the second foot-level; seven in the third; and four in the fourth. In the innermost six feet of the second Reach the sections were cut to a depth of 5 feet, instead of the customary 4 feet, but nothing was met with in any of the fifth foot-levels. The 'finds' included ninety-four teeth of Bear (many of them in pieces of jaw), four of Fox (in two pieces of jaw), one of Horse, one of Sheep, a very large quantity of bones (many of them much broken), one chert nodule, and three chips and flakes of chert and flint. The 'finds' were almost equally numerous in the two Reaches, but those in the second or inner Reach were comparatively very rich in specimens: thus, whilst the twenty-eight 'finds' in the first Reach contained in all no more than twenty teeth of bear, a single 'find' (No. 7,304) in the second Reach, contained also twenty teeth of bear and bones enough to fill a wheelbarrow, and the thirty 'finds' of this Reach yielded a total of seventy-four teeth of Bear.

The 'find' No. 7,297, consisting of bones and pieces of bone, met with in the second foot-level, on April 14, 1879, contained the proximal end of a left tibia, having on it at least five grooves or scores of different depths, and some of them having within them finer scores, parallel to their sides. When inspected with a lens, the surface of the bone showed several finer lines in various directions. As it may be doubted whether the scores were the teeth-marks of any animal, their origin is problematical.

Here again it may be remarked that several specimens lying on the surface of the Breccia, without covering of any kind, do not certainly or probably all belong to the era of that deposit. Indeed, the tooth of Sheep already mentioned, and a few bones belonging to the same 'find' (No. 7,261) are not only open to this cautionary remark, but from their aspect and mineral condition, belong, without doubt, to very recent times. The same may perhaps be said of the tooth of the Horse (No. 7,298), which lay also on the unprotected surface.

The specimens of flint and chert found in the Swallow Gallery are not entitled to more than a mere enumeration.

No. 7,260, a chert nodule, apparently never utilised in any way, was found alone in the third foot-level, January 29, 1879.

No. 7,273, a small chip or fragment of flint, was found alone, in the third foot-level, February 22, 1879.

No. 7,275, a small flake of flint, probably a fragment of a flake implement, was found on the surface, near a tooth of Bear and pieces of bone, February 24, 1879.

No. 7,301, a small chip of chert, was found in the first foot-level, with three teeth of Bear and numerous bones, April 22, 1879.

Your Committee, when treating last year of the flint implements which had then been found in the High Chamber, remarked, 'It is difficult to understand how the tools found their way to a branch of the Cavern so remote from the known entrances, and occupying so high a level. The problem is apparently insoluble except on the hypothesis that the workmen are approaching an entrance hitherto unknown; and as this supposition has been forced on the minds of the Superintendents by other and independent facts, they believe it to be most desirable to settle this question, if possible, as they do not doubt that it would give a definiteness to the explication of some of the Cavern phenomena.'—(Rep. Brit. Assoc., 1878, p. 129.)

The Superintendents have no doubt that the researches of the last twelve months have converted their 'hypothesis' of 'an entrance,' or, more correctly, of *entrances*, 'hitherto unknown,' into an established fact. They believe also that the facts prove that the said entrances—the Swallow holes in the High Chamber and the Swallow Gallery—were completely closed before the beginning of the 'Cave-earth' era, and have remained so to the present day.

The entrance in the Swallow Gallery was probably never available as a passage for any living animal; but there can be little doubt that any tolerably agile creature could readily have used that in the north-west corner of the High Chamber. That the roof dividing this branch of the Cavern from the open day is of very inconsiderable thickness is plainly indicated by the levels, as well as by the distinctness with which all external sounds are heard in that Chamber; and the 'series of limestone terraces,' mentioned already as leading up to the Swallow Hole, would form convenient steps for a man or any infra-human animal desirous of entering or leaving the Cavern.

Clinnick's Gallery.—Your Committee, in their Eleventh Report (1875), gave the following statement:—'The comparative paucity of specimens in Clinnick's Gallery induced the Superintendents, on December 1, 1874, to suspend operations in that direction for at least a time. The labour of seven months had been expended on it, during which the exploration had reached 75 feet from the entrance, where the Great Chamber discovered by John Clinnick may be said to begin.'—(Rep. Brit. Assoc., 1875, pp. 5-6.)

On May 24, 1879, when, as stated above, they left the Swallow Gallery, the workmen returned to Clinnick's Gallery, the only known branch of the Cavern the exploration of which has not been completed, that is to the depth of four feet below the base of the Stalagmitic Floor.

In wet weather this Gallery surpasses all other branches of the Cavern in the amount of drip from the roof; and this, on June 16, was so very

copious, on account of the unusually heavy rainfall the preceding day, as well as the previous saturated condition of the ground,[1] that the workmen were wet to the skin within two hours after beginning their work.

Since its resumption, the excavation in Clinnick's Gallery has been steadily carried on, and is still in progress; and at the end of July it had advanced 27 feet beyond the seventy-five mentioned in the Eleventh Report (1875). The deposit found there after the work was resumed was exclusively the Breccia, the upper surface of which dipped steadily in the direction in which the workmen advanced, and was 25 inches lower at the point reached on July 31, than at that at which the work was resumed in May. It was covered uniformly with Stalagmite, varying from 12 to 30 inches thick.

The paucity of specimens mentioned in the Eleventh Report still characterises this branch of the Cavern, for though upwards of two months have elapsed since the workmen returned thither, no more than three 'finds' have been met with in that time—a small fragment of a Bear's jaw, with a few splinters of teeth (No. 7,314), found in the second foot-level, on May 31, 1879, and two chert nodule tools (Nos. 7,316 and 7,317).

The chert tools, however, are of sufficient interest to repay the time and labour spent in exhuming them. No. 7,316 is of a light drab-coloured, granular chert, covered almost everywhere with a manganic (?) smut, but having a considerable patch of Breccia cemented to it with carbonate of lime. The outline of the tool is that of a trapezium with the angles rounded. It is 5·8 inches long, 3·1 inches in greatest width, and 2·3 inches in greatest thickness. The butt-end is almost square, and measures 1·4 inch by 1·3 inch. The tool attains its greatest thickness about 2 inches from this end, whence it tapers on each face to an oblique chisel-edge. The condition of the various edges is not inconsistent with the supposition that the tool had been slightly rolled. It was found alone on July 15, 1878, in the third foot-level of the Breccia.

No. 7,317 was unfortunately broken by the workman by whom it was found and dug out, and who, before he saw it, to use his own language, 'throw'd the pick into'n.' The surface of the fracture has a very white chalk-like aspect, but the application of hydrochloric acid causes no effervescence. Like the preceding tool, its surface is largely covered with a manganic (?) smut. In form the tool may be said to be somewhat pear-shaped. It measures 5·6 inches in length, 3·5 inches in greatest width, and 2·6 inches in greatest thickness, It was found alone on July 25, 1879, in the second foot-level of the Breccia, within 2 feet of No. 7,316.

It is perhaps noteworthy that the only other chert tool having, like Nos. 7,316 and 7,317, a blackened surface, which the Cavern has yielded, was the fine specimen, No. $\frac{1}{6411}$, met with also in Clinnick's Gallery, and described in the Committee's Tenth Report (Report, British Association, 1874, pp. 15–16). It was found, April 23, 1874, in the fourth foot-level of the Breccia, and was also a nodule tool, but not quite so large as the specimens described above.

Clinnick's Gallery, so far as it has been explored, varies from 12 to 4 feet wide and from 7·5 to 11 feet high. It consists of three Reaches, of

[1] Rain fell every day during the ten preceding days; the total fall amounted to 3·01 inches, of which ·97 inch fell on the 15th.

which the first or outermost extends in a northerly direction about 30 feet The Gallery then turns at right angles and extends westward about 25 feet, where it again, though with some irregularity, takes a northerly direction for 30 feet.

About 16 feet up the third or innermost Reach the explorer, by crawling up a steep sheet of stalagmite, formed on limestone rocks *in situ* on the western side, and, having reached the top, by wriggling vermicularly through a very small aperture, finds himself in a chamber from 10 to 12 feet long and broad, but not quite so high, where he soon comes to the conclusion that there is little or no chance of finding anything of interest to the palæontologist or the anthropologist. The walls and roof, however, are hung with a profusion of beautifully white stalactites, many of them in the form of long, thin, quill-like tubes, whilst others of larger volume assume various forms, but all of great beauty. From the floor there rises a forest of stalagmitic 'paps,' some of them nearly 2 feet high and 10 or 12 inches in circumference, and all promising, were time allowed, to become pillars reaching the roof. By letting himself down over a rocky ledge, about 4 feet high, at the inner or northern end of this chamber, the explorer enters a second chamber, about 25 feet long from south to north nearly, and 12 feet wide; where, though stalactites and stalagmites are almost as plentiful and as beautiful as in the ante-room he has just left, his attention is rather rivetted on the walls, and especially the roof, which are rugged, and angular, and shivered. That blocks of limestone have in great plenty fallen from them, and in times geologically recent, there cannot be a doubt, and their aspect is anything but calculated to inspire confidence in their present stability. Nevertheless, judging from the stalactites depending from the roof and the 'paps' rising from the floor, there can have been no very recent fall. The floor, telling much the same story as the roof and walls, is made up of masses of limestone, generally of no great size, with numerous pitfalls between them.

On its eastern side, the third or innermost Reach of Clinnick's Gallery opens into a large chamber, which the workmen have just begun to explore.

Palæontographical Society.—In 1878 your Committee had the pleasure of receiving from Professor A. Leith Adams, F.R.S., an application for permission to have drawings taken of any relics of mammoth they had found in the Cavern, for the purpose of illustrating the monograph on the 'British Fossil Elephants' which he is preparing for the Palæontographical Society of Great Britain. It must be unnecessary to add that the permission was at once granted, and that such specimens as he wished were forwarded to him without delay.

Professor Leith Adams has accordingly, in Part II. of his monograph (1879), directed attention (pp. 84, 85, 86, 91, 92, 94) to fifteen milk-molars found by the Committee in the deposit known as the Cave-earth, and has given natural-size figures of three of them (Nos. 1,063, 5,489, 5,774; see pl. ix., figs. 3 and 4, and pl. xii., fig. 2).

The principal facts connected with these specimens are set forth in the following Table:

Nos.	When and where found			Found with relics of	Characters
	Dates	Parts of the cavern	Foot-levels		
315	June 23, 1865	Great Chamber	4th	—	Upper third milk-molar
1059	Dec. 20, „	„	„	—	Lower „ „
1063	„ 21, „	„	„	—	Upper second „
1248	Feb. 10, 1866	„	„	—	Lower third „
2135	„ 13, 1867	Vestibule	„	—	„ „ „
2677	July 4, „	Great Chamber	2nd	—	„ „ „
2902	Oct. 18, „	Lecture Hall	3rd	—	Upper fourth „
$\frac{12}{3438}$	„ 6, 1870	Smerdon's Passage	4th	Hyæna, horse, megaceros, rhinoceros	„ „ „
$\frac{2}{3489}$	„ 21, „	„	„	Ox	Lower third „
$\frac{16}{4817}$	Dec. 24, 1869	North Sallyport	„	Hyæna, horse, rhinoceros, lion	Upper „ „
$\frac{11}{5379}$	Sept. 8, 1870	Smerdon's Passage	1st	Hyæna, horse, rhinoceros, badger, deer	„ „ „
5489	June 24, 1871	Sloping Chamber	4th	Hyæna	Upper fourth „
$\frac{2}{5774}$	Dec. 2, 1874	Cave of Rodentia	„	„	Lower first „
5968	July 30, 1872	Long Arcade	3rd	Bear	Upper third „
6066	Jan. 16, 1873	„	2nd	—	Lower „ „

Speaking of the enamel of the molars of the mammoth, Professor Leith Adams says, 'It is remarkably attenuated in teeth from the Arctic regions' (p. 79), and that 'all the teeth [of mammoth] from Kent's Cavern, Devonshire, show the Arctic type and have *thin* enamel' (p. 80).

Again, he remarks, 'The Arctic or typical crown represented by the North-Asiatic and North-American specimens on the one hand, and Kent's Cavern on the other, presents a decided contrast to the molars from Ilford on the Thames, where not only is the enamel thicker, but the teeth themselves are all much smaller. The same character [as to size] obtained in other parts of the skeleton' (p. 81).

The author describes the specimen belonging to the 'find' No. 1,063, figured in his pl. ix., figs. 3, 3*a*, 3*b*, 3*c*, as 'an excellent representative' of the antepenultimate or second milk-molar 'of the upper jaw, and probably of the right side.' 'The tips of the digitations of the four anterior plates being slightly detrited show,' he says, 'the owner to have been, at all events, not uterine' (p. 85).

Attention was directed in the Eighth Report (1872) to the specimen No. $\frac{2}{5774}$ in the foregoing Table. Mr. G. Busk, F.R.S., a member of the Committee, said then, 'I consider that it represents the very rare occurrence of a true mm. 1. . . . This is a very curious specimen, and, as regards the elephant, of remarkable interest' (Report, British Association, 1872, p. 37). Professor L. Adams adopts Mr. Busk's determination, and adds, 'This tooth is one of the smallest milk-molars of any elephant with which I am acquainted, and is even more diminutive than the first milk-teeth of the Maltese pigmy elephants. . . . The tips of one of the digitations show signs of detrition, and the well-formed and consolidated fangs give evidence, at all events, that the animal did not die in the womb. The probability is, therefore, that this very small tooth may be a rare instance of the *pre*-antepenultimate appearing in the lower jaw of the mammoth, its long divergent fangs leading to the belief that it belonged to the mandible' (p. 84).

Report of the Committee consisting of Mr. JOHN EVANS, Sir JOHN LUBBOCK, Major-General LANE FOX, Mr. GEORGE BUSK, Professor W. BOYD DAWKINS, Mr. PENGELLY, *and* Mr. A. W. FRANKS, *appointed for exploring certain Caves in Borneo.*

YOUR Committee have to report that with the grant of 50*l.* from the Association, a similar grant from the Royal Society, and a further sum of about 200*l.* from private sources, they have been able to prosecute an examination of various caves in Borneo, under the superintendence of Mr. A. Hart Everett, who has devoted himself to the task for a period of nearly nine months.

His final report upon his work has not yet been received, but it appears from his letters, and from the specimens which have been transmitted to this country, that nothing of special interest, either from an anthropological or a geological point of view, has resulted from his explorations. The animal remains discovered have all been of recent species; the human bones are probably of no very great antiquity, and none of the few objects of human manufacture which have been found can be regarded as of palæolithic age. Pending the arrival of Mr. Everett's final report it appears needless to enter into details, but it may be mentioned that upwards of twenty caves appear to have been explored in a more or less complete manner, and the principal objects found, after examination by some of the members of the committee, have been forwarded to the British Museum.

Although the examination of these caves has not, as was hoped, thrown any light upon the early history of man in that part of the world, it is still satisfactory that the examination should have been made, and the character of the cave-deposits ascertained by so competent an observer as Mr. Everett. The evidence obtained, though negative, is not without value, and those who are specially interested in cave explorations, and who have so liberally assisted in the present instance, cannot now be reproached with not having availed themselves of the opportunity afforded by Mr. Everett's presence of obtaining further information as to the contents of the Borneo caves.

It may be added that though for the most part the objects secured were unimportant, there were among the cave deposits a number of shells of land and fresh water mollusca, which have been examined by Colonel Godwin-Austen and have proved to belong to at least twenty-five genera and forty species, some of which are apparently new. Mr. Everett has been requested to devote some attention to collecting a larger series of these shells, but owing to the difficulties of postal communication it is possible that the request may arrive too late. Your Committee propose to communicate Mr. Everett's final report, together with any observations which seem called for on the specimens which are still to arrive, to the Royal Society.

After the reading of the above the following letter was received from Mr. Everett:—

Second Quarterly Report on the Bornean Cave Exploration.

To J. EVANS, Esq.

DEAR SIR,—I beg to submit the following Report of my work during past three months:—

Cave No. V.—As mentioned in my first Report, I was still occupied at the date of its despatch in the examination of this cave. *Excavation B* was continued across the low-level chamber to its left-hand wall, where the earth attained a thickness of about 5 feet. The contents preserved the character already noted throughout, and they yielded no sign of organic remains of any kind whatever. *Excavation C*, situated half-way up the steep entrance talus was carried to a depth of 4 feet only. The contents were washed, when their condition admitted of the employment of this process, with the result that a few bones of bats and small rodents, together with abundance of the usual land and fresh-water shells were met with; but nothing to warrant an extended working until the remains sent from the *D* excavation shall have been examined and reported upon. The earth in *C* working became concreted just below the surface to such a degree of hardness as to necessitate frequent blasting; but this stony concrete was irregularly distributed, the earth being in parts quite friable down to the bottom of the excavation. *Excavation F* was cut into a bank of pure guano, capped by a deposit of rotten stalagmite, about 1 foot thick. This bank is a small local deposit of only a few yards' extent. Neither bones nor shells occurred here. *Excavation D.*—I blasted out a small portion of the hard reddish-yellow concrete lying immediately below the ossiferous river-mud in this excavation; but seeing no sign of bones, and the hole filling with water, I did not work down to the limestone floor. I finally abandoned Cave No. V. on January 4, and transferred the workmen the next day to No. XIII.

Cave XIII.—This cavern consists of a simple large tunnel piercing the Jambusan hill from side to side (or rather that spur of it known among the Dyaks as Gunong Bak), about a quarter mile to the eastward of Cave No. V. The entrance is about 45 feet above the level of the plain; and the real floor, where the limestone rock has been exposed by the drip about the centre of the cave, is some 10 feet lower. I enclose a plan of the entrance hall, with one transverse and one longitudinal section of the deposits worked through. I have already consigned you to a sample of the ossiferous contents of the cave, together with specimens of the various deposits it afforded. These latter, I should mention, are all much wetter, and therefore harder and stiffer, when freshly exposed than will be apparent from their appearance when they reach you. I made no excavations in the interior part of the cave, where I found a great thickness of the usual tenacious yellow clay; but I cut one trench just within the entrance, and a second one somewhat in advance in it. The series of deposits met with were as follows:—

Excavation A.

Stratum 1.—A narrow band (1 to 4 inches thick) of black earth full of fragments of charcoal, broken cooking utensils, bones, &c., being the *débris* left in recent years by the Dyaks, when camping in the cave for the purpose of taking the nest-harvest. This layer was thrown aside after very superficial scrutiny. It is noteworthy that it contains sparingly the shells of a marine bivalve—a *Cardium*, I think (lot 108).

Stratum 2.—A hard stalagmitic layer (about 4 inches thick), coloured reddish by intermixture of clay, and containing a few land shells and remains of bats, which, however, appear to die out in the next succeeding stratum.

Stratum 3.—Concreted yellow clay (8 inches to 12 inches thick), without apparent stratification, and without organic remains. This stratum is sharply defined from the preceding one; but not so from Stratum 4, of which it is, in fact, an integral part. Both this stratum and the preceding required steady blasting throughout the excavation, and any remains they might have contained would have been likely to escape notice unless of large size or occurring in some abundance.

Stratum 4.—Unstratified reddish-yellow clay, with small water-worn gravel, and without any kind of organic remains. This stratum rested immediately on the limestone floor, which was worn into deep longitudinal furrows.

The dimensions of this excavation were $23' \times 6'$ to $7'$, and the depth varied to $6'$ in the deepest part. It was completed in six days, as it was not necessary to follow the tedious process of washing the contents. Section 1 coincides with the longer axis of the excavation, and *it is incorrect* in one particular, *i.e.* it shows the black band as subjacent to the deposit of clay marked 5, which is really below it.

Excavation B.

Stratum 1.—The black band, as in Excavation A.

Stratum 2.—A bed of river mud, indistinctly stratified, mixed with guano, and crowded with the remains of bats and of land and fresh-water mollusca, together with bones and teeth of a variety of mammalia, fish, and reptiles, the majority of which are much broken and waterworn. Greatest depth 4 feet. This bed corresponds to the ossiferous stratum of Cave V. Excavation D, with which it is essentially identical. The remains, however, obtained from XIII., B, are more varied and in better condition than those from Cave V.

Stratum 3.—Unstratified yellow clay, concreted, except in its uppermost part, into a hard stalagmitic rock. This deposit corresponds to the strata 3 and 4 of Excavation A. It contains shells and a few bones. Owing to the scarcity of these latter, and also to the influx of water by underground drainage, I did not continue this trench down to the limestone floor.

In this excavation it was needful to wash the whole of the river-mud in sieves, which caused the work to be excessively slow. During the process a small V-shaped fragment of stone, seemingly artificial, was found. It is that marked 110 in the Catalogue. If this fragment is considered to be undoubtedly of human workmanship, it forms the first evidence of the co-existence of man in the district with the fauna of the river-mud horizon, and as such is not without interest. A more important result of the exploration of No. XIII. is the proof obtained—meagre though it is—of the presence of the remains of mammals in the yellow clay lying below the river-mud deposit.

During the quarter, I have visited fourteen additional caves in the Paku and Bidi districts. One of these, known as the Guah Kokan in the Kapoh hill at Bidi, is of great size, has seemingly a considerable thickness of deposits, and is situated at a height of upwards of 100 feet, in the face of a perpendicular cliff. It is very large for the few men at my command to make an adequate impression on, but I will attempt it if no better offers within the next few days. Before the completion of the ensuing quarter I hope to be able to report having visited the ossiferous

cavern discovered by Mr. Coulson, to the locality of which I believe I have at length a clue.

I am, dear Sir,
Yours faithfully,
(Signed) A. Hart Everett.

Sarawak, March 8, 1879.

List of Remains, &c., found in Sarawak Caves, Borneo.

No.

1. Remains of raptorial bird (recent). Obtained from Cave No. V. at Jambusan. Found on the surface of the earth, at the bottom of the deep pit at the farther end.
2. Molar tooth and fragment of bone. Purchased from Chinese gold-washer. Found in the swampy flat of alluvium, débris of limestone, stalagmite, and veinstones, &c., which skirts the south-east base of the Busan hills between them and the village of Paku.
3, 4, 5. Teeth procured at different times by Chinese washing for gold in the same situations as No. 2. All purchased.
6. Portion of jaw with teeth, apparently of wild hog, procured from the silt at the mouth of Cave No. VI. Originally brought from the interior when the cave was examined for gold.
7. Fragments of bone found in same locality as Nos. 2, 3, 4, 5. Purchased from Chinese gold-washer.
8. Seven teeth of a large deer (?), with fragment of bone. Purchased from Chinese gold-washer, and found in the same locality as No. 7.
9. Human remains. Procured from Cave No. II. at Paku. Collected by myself. (See Report.)
10. Remains of wild hog, apparently. Purchased from a Dyak, who stated that they were found far within a cavern too contracted to allow of the passage of a living pig, if it could have climbed the precipitous hill half-way up which the cave opened, which he thought impossible. Being dissatisfied with the price paid, he refused to show this cave.
11. Bones and teeth purchased from a Malay gold-washer. Found in the pan in washing the earth in Cave No. III. Cave visited by myself. (See Report.)
12. Human remains purchased from another Malay gold-washer. Found in Cave No. VIII. close to Paku, in the Busan hills, and near the mouth of the cave. Only slightly covered with earth.
13. Bones and teeth purchased from Dyaks. Found within a narrow cave high up on one of the hills near the Tagora road—Cave No. IX. The bones were either on the surface of the cave earth or but slightly buried.
14. Remains of a large Chelonian, purchased from Dyaks. Found in Cave No. VII. Jambusian hill, tightly wedged in a fissure of the rocky floor which had been laid bare of a thick bed of very tenacious clay at this spot. The bones seen *in situ* by myself.
15. Remains of bats, &c. Collected from the surface of the inner talus, at the entrance of the Jambusian cave (No. V.).
16. Remains found close to the surface in Excavation B, Cave V.
17. Remains found at depth of 1 inch to 18 inches in Excavation D, Cave V.
18. Teeth, &c. Cave V. Excavation D. Found about 18 inches below the surface.
19. Ramus of lower jaw of small rodent. Cave V. Excavation D.
20. Remains of bats, &c., from surface of inner talus. Cave V.
21. From the same situation as the preceding.
22. Bones. Cave V. Excavation D. Found about 2 feet below the surface.
23. From the same situation as the preceding.
24. Bones and land shells. Cave V. Excavation D. From uppermost foot-level of the deposit.
25. Land shells from the inner talus. Cave V.
26. Land and fresh-water shells from cave-earth of Excavation B, Cave V.
27. Bones with *Potamides*. From upper part of deposit in Excavation D, Cave V.

28. Bones and land shells. Excavation D, Cave V. About 2 feet below the surface.

29. Purchased from Chinese washing gold in the Paku flat.

30. Miscellaneous bones, jaw of rodent, &c. Excavation D, Cave V. Nearly 3 feet below the surface.

31. Remains from Cave No. II. Found in a little calcareous earth on a ledge just without the mouth.

32. Bones from a deep fissure cavern at Paku. Found in gold-washer's refuse. The whole contents of this cave had been disturbed by the Chinese. Purchased from Dyaks.

33. Fragment picked up on the Busan hills.

34. Bones and teeth purchased from Malays. Found in a cave at Paku.

35. Single rib-bone. Found by a Dyak partly buried in cave earth at Jambusan. The finder made a search for more, but without success.

36. Remains of a young *Macacus* (?). Found on the surface within a cave near Paku.

37. Teeth, land shells, &c. Excavation D, Cave V.

38. Teeth of *Hystrix*, &c., &c. Excavation D, Cave V. About 3 feet below the surface.

39. Purchased from gold-washers. Obtained from the Paku flat.

40. Purchased from Dyaks. Obtained from a cave in the Jambusan Hill.

41. Remains of *Hystrix*. Found on the surface. Cave at Jambusan.

42. Carapace of tortoise. Found on the surface. Cave at Jambusan.

43. Teeth and bones purchased of gold-washers. From the Paku flat.

44. Teeth and bones purchased from Dyaks. Found in a cave in the Jambusan hill.

45. Human remains, &c. Partly purchased, partly collected by myself in Cave No. XIV. Cf. Report.

46. Remains of bats. Excavation E, Cave V.

47. Reptilian remains. Surface of a cave in Jambusan hill.

48. Teeth and bone. From the surface of a cave in the Jambusan hill.

49. Pottery, teeth, marine shell (*Cypræa*), &c., found associated with the human remains in Cave No. XIV., at the second milestone on the Tagora road. Cf. Report.

50. Chelonian remains. Surface of a cave half-way up the southern face of the Busan hills.

51. Bone. Purchased from Chinese. Found in a cave at Paku.

52. Chelonian remains. Purchased from Chinese gold-workers, and found at a spot in the Paku flat where the contents of a cave were washed in former years.

53. Skull of *Helarctos*. Found at about 3 feet depth in a cave in Gunong Jawang. Bears marks of a cutting instrument.

54. Chelonian remains. Obtained in the Paku flat at a spot where the contents of adjacent caves were formerly washed for gold. Purchased.

55. Skull of *Simia satyrus* ♂. Obtained from same situation as the preceding. The gash cutting through the parietal and other bones on the right side of the cranium was probably caused by the tools of the gold-seekers when the skull was first exhumed. It has since been again covered with earth for some years. The occipital foramen bears marks of a sharp cutting instrument. The skull has evidently been exposed to smoke, and it might stand for one which has hung griming for years in the smoke of the head house of the Dyaks on Siranbu.

56. Cervine, molar, and other remains. Cave No. III.

57. Teeth of *Simia*, fragments of chelonian, &c. The Paku plat. Purchased.

58. Skull and portion of skeleton of a small monkey, purchased from Dyaks. They stated that the remains occurred in a cave near the summit of one of the Jibong group of hills, at a long distance within the cave ('distant from the entrance the burning of one torch'), and from their description they appeared to have been laid bare by the washing of water.

59. Quadrumanous remains from the same locality as the preceding, but from a distinct cave situated only half-way up the hill.

60. Remains of *Cervus* and chelonian from the swamp at the base of the foregoing hill.

61. Cervine remains. Purchased from Dyaks, who said the bones were found in one of the Jambusan caves about half-way up the hill. From the Dyaks' description I understood that these bones had been laid bare by the drip over the spot where they rested.

62. Portion of skull with two molar teeth. From a cave on the water-level in the Jambusan hill (No. XVI.).

63. Bone found on the surface in the interior of Cave XIV.

64. Two lower jaws of a carnivora in same Cave XIV., at about 18 inches' depth from the surface.

65. Two lower jaws (two halves) of Cervus. Obtained by myself in the same cave as No. 62, partly embedded in calcareous earth.

66. Teeth, apparently of wild pig. From a cave in the Jambusan hill.

67. Skull, &c. Obtained from Dyaks, who affirmed that these remains were lying in a narrow oblique fissure, connecting one of the Jambusan caves with the top of the hill, and that the reason why some of the bones are stained with smoke is that the fissure opened immediately above a flat ledge of rock on which the Dyaks were accustomed to light their fires for cooking, so that the smoke escaped habitually up the fissure. I suspect that the smoke-coloured remains may have belonged to recent animals eaten by the Dyaks in the cave when taking the nest-harvest.

68. Purchased from Chinaman. Found on a heap of gold-washers' refuse, the produce of a fissure at Paku, the mouth of which is situated about 50 feet above the water-level. Only bones found. Cave No. XVIII.

68. Teeth. Cave at Jambusan. Obtained from Dyaks. (The number inadvertently repeated.)

69. Human remains brought from a cave at Ahup. Said to be about 3 fathoms from the entrance, the cave being situated in the upper half of the hill. These bones lay on the surface, but the finder did not dig to see if any were below.

70. Remains purchased from a Malay. They occurred in a cave on the hills abutting on the Tagora Road. The cave is situated in the upper part of the hill. The fragment of jaw with teeth was found near the entrance; the other teeth occurred at some distance within, and together; and the bones in the innermost recess of the cave, which is extensive, only one rib showing on the surface, and the remaining bones at depths varying up to 12 inches.

71. Teeth of *Simia*. Found by myself in the refuse on the surface of which the large bones No. 68. were procured by the Chinaman. Cave No. XVIII.

72. Teeth of *Simia*. Purchased from a Malay, who met with them in a fissure close to Cave No. III., the floor of which is 8 fathoms below the entrance —the latter being situated some 50 or 60 feet above the water-level.

73. Mollusca from Cave V. Excavation D.

74. Various Teeth. Cave V. Excavation D.

75. Lower jaws of rodents, &c. Cave V. Excavation D.

76. Vertebræ, chelæ of crustacea, fish scales, &c. Cave V. Excavation D.

77. Human remains, pottery, &c., brought from a cave in the Ahup hill.

78. Remains, apparently of wild pig. Found by Dyaks in one of the higher caves at Jambusan.

79. Remains of carnivore. Found by Dyaks in a cave at Jambusan.

80. Simian remains. Said to have been procured from Cave XVIII.

81. Bones. Said to have been obtained in an old gold cave at Piat.

82. Miscellaneous remains. Cave V. Excavation D.

84. Two Cervine teeth. Found by Malay gold-washer in a deep fissure at Paku.

85. Molar of pig. The Paku Flat. Found by gold-washers.

86. Land and fresh-water Mollusca. Cave V. Excavation G.

87. Bones of bats, rodents, &c. Cave V. Excavation G.
88. Teeth of pig and of a carnivore. The Paku flat. Found by gold-washers.
89. Two fragments of bone. Crows. Said to have been obtained from same situation as No. 88.
90. Fragments of bone. Crows. Found by Malay gold-washer in a fissure at Paku. (Radius of Bos)-
91. Bones obtained from the Kawa Cave near Bidi. This cave is considerably above the present water-level, and the bones are said to have lain on the bare floor, there being no earth. Bones of a young pig, apparently roasted. The cave is a deep fissure descended by means of ropes. Purchased from Malays.
92. Cervine molar. The Paku flat.
93. Ditto and pig. Ditto, fragment of bird humera.
94. Molar of pig with fragment of bone. The Paku flat.
95. Teeth of pig. From a cave in the Eusunah gorge, near Paku.
96. Bones and teeth. The Paku flat. Young deer, &c.
97. Three teeth. Large deer. Ditto pig.
98. Various remains. Cave V. Excavation G. Bats and small rodent.
99. Bats and small rodents.
100. Lower jaw of *Simia satyrus*. Purchased from Chinese gold-worker. Doubtfully from a cave.
102. Fragments of bone. From heap of gold-workers' refuse in Cave No. I.
104. Molar of pig, incrusted with crystalline stalagmite. Found by Malay gold-washer at Paku.
105. Sample of remains (three boxes) washed from the river-mud in Cave No. XIII. Excavation B. Stratum 2.
106. Fragments of bone and teeth of pig (?), &c. Cave XIII. Excavation B. Stratum 3.
107. Chips of quartz, artificial? Cave XIII. Excavation B. Stratum 2.
108. Cardium. Cave XIII. Excavation B. Stratum 1.
109. Various teeth. Cave XIII. Excavation B. Stratum 2. Chiefly pigs.
110. Portion of worked stone. Cave XIII. Excavation B. Stratum 3.
111. Skull of *Simia satyrus*. Said to have been found in a cave at Paku. Doubtfully genuine, as regards its alleged situation.

Fifth Report of the Committee consisting of Professor HULL, Rev. H. W. CROSSKEY, Captain D. GALTON, Mr. GLAISHER, Mr. H. H. HOWELL, Professor G. A. LEBOUR, Mr. W. MOLYNEUX, Mr. MORTON, Mr. J. ROBERTS, Mr. PENGELLY, Professor PRESTWICH, Mr. JAMES PLANT, Mr. MELLARD READE, Mr. W. WHITAKER, *and* Mr. DE RANCE (*Reporter*), *appointed for investigating the Circulation of the Underground Waters in the Jurassic, New Red Sandstone, and Permian Formations of England, and the Quantity and Character of the Waters supplied to various Towns and Districts from these Formations.*

YOUR Committee had this year hoped to submit a general report of the capabilities of the Permian, Triassic, and Jurassic formations, and to close the inquiry which you entrusted to them. This has been found impracticable from several causes, especially from the fact that important sinkings for water are being carried out in the Staffordshire and Midland district taken charge of by Mr. Molyneux and Mr. Plant, who cannot report until they are completed. Secondly, your Committee find the more

their labours become known, the greater inclination is shown by engineers and contractors to furnish information, and the greater tendency is exhibited to make available our underground water for the purposes of consumption. And they are of opinion, that until it becomes the duty of a Government Department to collect the various information accruing from day to day, it is important that the Committee should be reappointed, and further that their inquiry should not be limited to certain formations, but should extend to the whole of the permeable formations of England.

The attention of your Reporter has been specially given since the last meeting to the estimation of the areas of water-bearing formations in the various river-basins, and to the extent to which they may be expected to underlie the more impermeable clays and marls; towards this object he has personally examined a large area of the country, and endeavoured to ascertain how far the rain falling in certain river-basins is carried by the dip into other hydrographic areas. These results he is prevented laying before you in detail through illness, brought on by a railway accident; but the following totals may be found useful, giving the Permian and Triassic formations in fourteen groups of the 215 river-basins of the Ordnance Survey Catchment Basin Map:—

River Basin Groups	New Red Sandstone	New Red Marls	Total
	Square Miles	Square Miles	Square Miles
Tyne and Tees	100	70	170
Ouse and Trent	1171	1870	3041
Witham and Ouse	—	6	6
Exe and Dart	315	49	364
Cornwall and Devon	10	—	10
Severn, &c.	438	1393	1831
Neath to Clywd	52	—	52
Dee to Duddon	1070	850	1920
Esk to Eden	37	—	37
	3193	4238	7431

Of the 3041 square miles of Trias in the Ouse and Trent basins, 200 of Red marls probably rest directly on the non-water-bearing Palæozoic rocks of Charnwood Forest age. The 1171 square miles of sandstone, at 5 inches absorption, would give a daily average of 234 million gallons, or a supply for four-and-a-half million persons; the population is probably not less than six millions; the demand is here in excess of the supply, the deficiency is made up by moorland surface waters from the elevated table lands of the Penine chain. The underground supply is, however, only pumped to a fraction of its yielding capacity.

In the Severn and (Bristol) Avon basins 438 square miles of sandstone, with 10 inches' percolation, would yield a supply for three-and-a-half million persons, at fifty gallons per head; but part drains away underground into the Trent basin, between the north and south Staffordshire coal-fields in its northern area, and into the Thames basin in its southern area. The Triassic sandstones in the south-east area towards the Thames basin are thinning rapidly, and much of the 1393 square miles red marls is not supra-pervious, and rests on Palæozoic impermeable rocks.

South of the Mendips 315 square miles of Triassic sandstone crop to

the surface, which, on 10 inches' absorption, would yield a daily average of 126 million gallons, or a supply for two-and-a-half million persons; and is available for the supply of Exeter. In this district further information has been collected by Mr. Stooke, C.E.

In the Lancashire and Cheshire plains New Red sandstones crop over 1070 square miles, which, at 10 inches' absorption, would give a daily average yield of 428 million gallons, or a supply for eight-and-a-half million persons at fifty gallons per head. The new boring at Bootle, carried to a depth of 1300 feet, by Messrs. Mather and Platt, for the Corporation water-supply of Liverpool, reported on last year, is now completed, but further details are deferred until pumping has determined how far the underground yield of Liverpool is increased by this sinking. Some doubts having been thrown on the determination of the age of the hard coarse-grained rock, met with under the Pebble Beds at Bootle, which your Reporter considers to be a compact variety of the Lower Mottled sandstone, he is glad to be able to state the correctness of this opinion is proved by a boring made for the Warrington Waterworks Company, at Winwick, by Mr. E. Timmins, of Runcorn, which, after passing through the base of the Pebble Beds, and a compact 'millet seed'-grained rock, identical with that of Bootle, again entered soft, loose, red and white sand, of the Lower Mottled sandstone type, which in its turn again rested on the Upper Coal Measures, including a limestone probably referable to the age of the Ardwick limestone of Manchester.

Appendix A.

Triassic Wells, &c., South Devon.

By Thos. S. Stooke, C.E., Kingskerswell, Newton Abbot.

Lyons Holt Spring, situate near Exeter, on the New Red sandstone formation at a height of about 126 feet above sea level.

The water yielded in the twenty-four hours being about 47,000 gallons, and which is conveyed through pipes to various parts of the city of Exeter, being distributed by means of drinking fountains.

The water is much valued, and Mr. Perkins of that city supplies the following analyses, viz.:—

100,000 parts contain free ammonia	·004
Albuminoid ammonia	·0074
Nitrogen as nitrates and nitrites	·236
Chlorine	5·7

Name of Individual or Company applied to—

W. Shepherd & Son.

1. Lunatic Asylum, Exminster. **2.** 100 ft. **3.** Depth of shaft 117 ft., diameter 9 ft.; from surface to bottom of bore-hole 473 ft. 6 in. **4.** Before pumping 30 ft. above bottom of shaft; after pumping 12 hours 25 ft.; restored in 6 hours after pumping. **5.** 200,000. **6.** N.B.—This bore-hole has only very recently been completed. **7.** The new pumping machinery not yet reported at work. **8.** The water is very good, and is highly valued by the authorities. **9.** Conglomerate, chiefly red sandstone. **10.** Yes. **11.** No. **12.** No. **13.** No. **14.** No. **15.** No.

J. M. Drew.

1. Bridge Mills, Silverton. **2.** About 80 ft. **3.** 20 ft.; 4 ft.; 237 ft. 6 in. **4.** 20 ft. and 34½ ft. from surface. **5.** 180,000. **6.** No. No. **7.** No. **8.** Not analyzed further than to prove it to be free from iron.

		Feet.	
9.	Sand	94	Bore-hole, strata.
	Rock	27	
	Marl	23	
	Clay and greensand	30	
	Gravel, water	5	
	Hard clay	16	
	Red rock	16	
		217	

10. Very little. **11.** No. **12.** No. **13.** No. **14.** No. **15.** No.

C. R. Collins.

1. Hele Paper Works. **2.** About 90 ft. **3.** 20 ft., 10 ft. diameter, 120 ft. 6 in. **4.** Pumps always at work, Sundays excepted, suction pipes 30 ft. below surface. **5.** 259,000 gallons. **6.** Yes, a few feet in very dry weather. **7.** Yes, but plenty of water always available; variation 15 to 20 feet in dry weather. **8.** None; no, very pure. **9.** New Red sandstone. (No wells were sunk before I came here). **10.** Yes. **11.** No. **12.** Not known. **13.** No. **14.** No. **15.** No.

Norman & Pring.

1. City Brewery, Exeter. **2.** 25 ft. **3.** 70 ft.; 4 ft. diameter; 270 ft.; 4 in. diameter. **4.** Cannot tell, as the adits hold several thousand gallons. **5.** About 4000. **6.** No. **7.** No; no variation.

		Grains
8.	Organic and volatile matter, including ·112 of oxidisable organic matter	1·15
*	Oxide of iron and alumina, with traces of phosphoric acid	·15
*	Sulphate of lime	6·24
*	„ of magnesia	·48
*	Nitrate of „	·99
*	Chloride of sodium	4·79
*	Carbonate of soda	9·75
*	Soluble silica	·10
		23·65

* Total solid matter per gallon, dried at 270° F.

		Feet
9.	Gravel	15
	Shellet	85
	Alternate layers of trap and red shellet	54
	Blue shale or clay	90
	Water, sand	3
	Blue shale or clay	15
	„ „	8
		270

10. No. **11.** Yes. **12.** No. **13.** No. **14.** No. **15.** No.

Gillman & Co.

1. At Treus Weir, near Exeter. **2.** About 20 ft. **3.** 20 ft. well; 240 ft. bore; 7 in. **4.** Pumping continually going on; lowers about 5 ft. **5.** 250,000 from high level. **6.** Never diminished for 10 years; more water in the autumn and spring. **7.** Never affected by rain. **8.** Considerable quantity of carbonate of lime and chloride of sodium. **9.** Entirely in red rock; the bore is not through the rock, but ends in it. **10.** Gravel and springs. **11.** No. **13.** No. **14.** No. **15.** No.

J. M. Drew.

1. Kensham Mills, Hele. **2.** About 100 feet. **3.** 40 ft.; 5 ft.; 200 ft.; 7 in. **4.** Pumps always at work except Sundays; suction pipe 30 ft. under surface. **5.** 170,000 gallons. **6.** Yes; not diminished. **7.** Yes, but no register of water levels has been kept. **8.** None; no. **9.** Bore-hole pierces the New Red sandstone. **10.** Yes. **11.** No. **12.** No. **13.** No. **14.** No. **15.** No.

Appendix B.

Report on the Water in the Triassic Sandstones at West Kirby, Cheshire.
By Isaac Roberts.

In the year 1877 I was requested by the Hoylake Waterworks Company (then just formed) to report upon the advisability of sinking a well on Grange Hill at West Kirby, which is distant about $1\frac{1}{2}$ miles to the south of Hoylake, with the object of obtaining a supply of water for the inhabitants of Hoylake and West Kirby.

On making a careful survey of the private wells in the neighbourhood of the proposed well, I determined the surface of the water plane in the rock to be 30 feet above the Ordnance datum at the highest part of Grange Hill, and 22 feet above the datum near the plain at the foot of the hill, and I reported that if a well were sunk at the point indicated by the company's engineer, a point 219 feet above Ordnance datum, the surface of the water plane would be reached about 195 feet below the summit of Grange Hill.

The sinking of the well was commenced about twelve months ago, and on visiting the site on the 11th of this month (July 1879), I found the well sunk 205 feet in depth, and the surface of the water plane 186 feet 5 inches below the point on the Grange Hill which I have already referred to, thus agreeing very closely with my calculations made in the year 1877.

The well on Grange Hill is distant about a mile from the river Dee, which is the nearest outlet for the discharge of the rainfall upon the hill and which passes through its mass into the sea. It is therefore demonstrated that the inclination of the water plane within the Triassic rocks of this district does not in any case exceed 30 feet in altitude to one mile in horizontal distance, and as the natural water level in the rocks of this district has not hitherto been materially disturbed by pumping, the inclination of the water plane given above will probably be, within narrow limits, the normal in all similar rocks.

The rock which forms Grange Hill is marked 'Pebble Beds' of the Bunter on the maps of the Geological Survey, but in examining the well which is now being sunk it appears probable that an error has been made in so naming them, for the lithological characteristics of the rocks agree better with the base of the Keuper forming the surface of the hill, and 'upper soft red' or 'mottled' sandstone beneath, than with 'pebble beds' as marked on the maps.[1]

Appendix C.—*Jurassic Wells, &c.*

Name of Member of Committee asking for information, W. Whitaker.
Name of Individual or Company applied to:—

Messrs. S. F. Baker & Sons.

1. Farringdon, Berks. **1*a*.** 1871. No. **3.** From surface to bottom of boring, 114 ft. 6 in.; upper portion, $5\frac{1}{2}$ ft.; and lower portion, $4\frac{1}{2}$ ft. diameter. **5.** Should say about 70 gallons per minute.

[1] The error Mr. Roberts refers to is rectified in the new edition of the Geological Survey Map of the district.—C. E. De R.

	Ft.	In.
9. Clay, with sand and limestone	6	6
,, very sandy	4	0
Blue and grey clay and calcareous grit . . .	59	0
Fine sand	23	0
Grey sand and clay, with water	22	0
	114	6

Messrs. Baker & Sons.

1. Gillingham, Dorset. **1*a*.** Unaware of date of sinking. Deepened by boring 1878. **3.** To bottom of shaft, 60 ft. from surface; to bottom of boring, 86 ft. 8 in. from surface. **4.** Before pumping, about 50 ft. from surface; after pumping, about 70 ft. from surface. **5.** Pump only equal to about 20 gallons per minute. Could not exhaust at this. **9.** Well sunk through clay and rock. Boring through clay, hard sand, and rock.

Name of Member of Committee asking for information, James Plant.

1. Hinckley, Leicestershire. **1*a*.** 1875. Deepened 30 ft. since. **2.** About 350 ft. O.D.? **3.** 30 ft.; diameter 6 ft. Bore various, 11 in. to 7 in.; 520 ft. deep. **3*a*.** None. **4.** 450 ft. **6.** Not known. **8.** Sulphate and carbonate of lime was first found; this was due to the water from the red marl and gypsum beds above the waterstone; it is now partially stopped out, and will be entirely so when shaft is sunk.

9. Section of Shaft and Bore at Hinckley, Leicestershire. 550 feet.

	Depth	Shaft and Bore	Rocks penetrated
Glacial clays and sand.	Feet 50		Brown clay, *with pebbles* (a few seams of sand).
	50		Sand, *no pebbles* (a few seams of clay).
	50		Brown clay, *no pebbles*. At base, 3 feet *red clay*, with stones.
	3		
	30		f. 6′. Upper Keuper sandstones.
	217		f. 6. Red marl, with gypsum in bands (thin) and nodules. (Water at *base* of each band of gypsum).
	150		f. 5. ‘Waterstones,’ thin bands of red and white sandstones, with thin ‘wayboards’ of red clay; thicker red and white sandstones at base of formation. ‘Waterstones’ not penetrated, but estimated to be altogether 320 feet. Bore-hole to be carried to 650 feet.
	550		

Thick line represents permanent level of water for four years, standing 300 feet above ‘waterstones.’

10. Yes. **11.** Yes. **12.** An upthrow fault, distant two miles east; amount of throw from 600 to 700 ft. **13.** None now. **14.** None known. **15.** None.

1. One mile west of Oakham, Rutlandshire. **1*a*.** About five years, and deepened several times. **2.** About 350 ft. O.D. **3.** Shaft 80 ft., diameter 7 ft. **3*a*.** None. **4.** 40 ft.; level not perceptibly reduced. **4*a*.** Same height. **5.** Not estimated. **6.** Not observed to vary. Is fed from hills 2 miles each; 755 ft. O.D. **8.** Very sweet and pleasant water; used solely for brewing.

	Rocks	Depth in Feet	
9.	Drift	4	
	G 3, upper lias clay	30	
	G 2, marlstone rock	18	Lias formation.
	G 2′, „ sands	28	
		80	

Shaft is about to be carried deeper, as a larger supply of water is wanted.

10. None seen. **12.** Fault 5 miles S.W.; several faults about 6 miles S.E. This fault is 6 miles long, running E. and W. **13.** None. **14.** None. **15.** No.

Appendix D.—*Form of Inquiry now circulated.*

1.—*Position* of well or wells with which you are acquainted.

1*a*.—Date at which the well was sunk. Has it been deepened since?

2.—Approximate *height* of the same above the mean sea level.

3.—*Depth* from surface to bottom of shaft or well, with diameter. *Depth* from surface to bottom of bore-hole, with diameter.

3*a*.—What is the extent and number of the horizontal drift-ways, if any?

4.—Height at which water stands *before* and *after* pumping. Number of hours elapsing before ordinary level is restored after pumping.

4*a*.—Height at which the water stood when the well was first sunk, and height at which it stands now.

5.—*Quantity* capable of being pumped in gallons per day.

6.—Does the *water level* vary at different seasons of the year, and how? Has it diminished during the last ten years?

7.—Is the ordinary *water level* ever effected by local rains, and if so, in how short a time? And how does it stand in regard to the level of the water in the neighbouring streams, or sea?

8.—*Analysis* of the water, if any. Does the water possess any marked *peculiarity*?

9.—Nature of the rock passed through, including cover of drift, with *thicknesses*.

10.—Does the cover of drift over the rock contain *surface springs*?

11.—If so, are they entirely kept *out* of the well?

12.—Are any large *faults* known to exist close to the well?

13.—Were any *salt springs* or brine wells passed through in making the well?

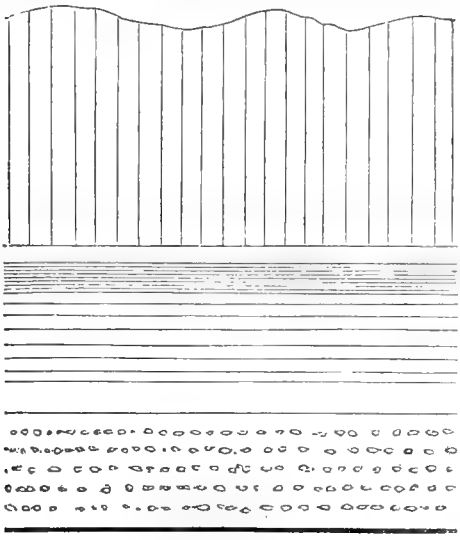
14.—Are there any *salt springs* in the neighbourhood?

15. Have any wells or borings been discontinued in your neighbourhood in consequence of the water being more or less *brackish*? If so, if possible, please give section in reply to query No. 9.

Report of the Committee, consisting of the Rev. MAXWELL CLOSE, Professor W. C. WILLIAMSON, *and* Mr. W. H. BAILY, *appointed for the purpose of collecting and reporting on the Tertiary (Miocene) Flora, &c., of the Basalt of the North of Ireland. Drawn up by* WM. HELLIER BAILY, *F.L.S., F.G.S. (Secretary).*

THE discovery of plant-remains in a deposit of brown and red bole under a thin bed of lignite, and immediately over a thick bed of conglomeritic or pisolitic iron ore, interstratified with the basalt of County Antrim, was facilitated by the excavations made for extracting this valuable iron ore, which has been found to extend over a considerable district of the North of Ireland, having been largely worked at various places.

The locality which has yielded the largest number of specimens is at and close to a cutting through basalt on the Belfast and Northern Counties Railway at Ballypalady, about seven miles east of Antrim. The section observed at that place, and supplied to me by the late G. V. Du Noyer, District Surveyor of the Geological Survey of Ireland, was the following, that gentleman also having sent me the first consignment of these interesting fossils for examination:—



1. Basalt, 15 feet.
2. Layer of brown earth, 3 inches thick.
3. Layer of impure earthy lignite, 8 to 12 inches.
4. Bed of brown earth or bole, passing into red at the lower part, and graduating into the plant bed, No. 5.
5. Plant layer, 4 to 8 inches thick.
6. Bed of pisolitic iron ore in ferruginous earth, 3 feet exposed.
7. Rails resting on basalt.
7. Basalt overlying chalk, thickness variable.

A notice of these plants, as well as some accompanying insect remains, was communicated by me in 1869 to the Geological Society of London.[1]

Since then I have visited the locality several times, always obtaining fresh materials and increasing the list of species. In addition to these, and to the use of the specimens in the collection of the Geological Survey, I am indebted to William Gray, Esq., F.G.S., and William Swanston, Esq., F.G.S., of Belfast; the Rev. Dr. Grainger, of Broughshane, near Ballymena; to the Belfast Natural History Society; and to the Director of the Natural History Museum of Science and Art, Dublin, for permission to draw and describe the specimens in their several collections.

[1] *Quarterly Journal Geol. Soc. of London*, vol. xxv. p. 357, plates xiv. xv.

In working the iron ores of this district there are other localities where beds of lignite and plant-remains have been observed, but none of them up to the present have been found to be anything like so rich in the remains of a fossil flora of so decided a character as the place just described, although it would be highly desirable to investigate occasionally places where similar excavations are being carried on.

The existence of another very interesting fossil plant locality, evidently of the same age, near Glenarm, was kindly communicated to me by Mr. William Gray, who was good enough to accompany me from Belfast to Glenarm, where, notwithstanding the severity of the weather (and it was snowing hard at the time), we succeeded in obtaining a good number of specimens; the material in which they are embedded, a light grey, laminated marl, being lithologically quite different from that of Ballypalady, although identical species occur at both localities.

On the east shore of Lough Neagh, at Sandy Bay, and in the bed of Glenavy river, near the same place, in drift deposits and in loose water-worn masses, the celebrated silicified wood is found; it is for the most part coniferous,[1] the structure being beautifully preserved, exhibiting the typical characters of the Cupressinæ, or cypress group. The silicification in all probability was caused by water holding silica in solution, although not by the water of Lough Neagh. The popular idea that the waters of this lake possessed petrifying properties has been satisfactorily shown to be fabulous, and that the lake itself in all probability did not exist at the period when this silicification took place.

Accompanying the silicified wood on the shores of Lough Neagh are also water-worn pebbles of fine granulated iron, which, on being broken, disclose the impressions of plants, amongst them a fern, *Hemitelites*, twigs of *Sequoia Couttsiæ*, and leaves of dicotyledonous trees in beautiful preservation. Where a fresh fracture has been made, the finely reticulated structure of the leaf is shown, and in the Sequoia the woody character of the twig, apparently unchanged, is preserved in the cavities made by its impression in the ironstone.

Up to the present time I have been enabled to enumerate at least twenty-five species from these Miocene deposits of the North of Ireland. They are as a group most closely allied to the fossil flora of North Greenland (described by Professor Heer in the 'Philosophical Transactions,' 1869). Some of them are certainly identical, such as *Sequoia Couttsiæ*, (Heer), occurring at Bovey Tracey, shores of the Baltic, and North Greenland; *Phragmites Œningensis* (Ad. Brong), the well-marked leaves doubtfully referred by Heer to the family Menispermaceæ, and named by him *McClintockia Lyalli*; and *M. trinervis*, the fruits or seeds of *Nyssa ornithobroma* and *Viburnum Whymperi*, together with a leaf of the latter species; also leaves of *Alnus*, closely allied if not identical with *A. Kefersteini*; *Platanus Guillelmæ*, and *Juglans acuminata*. It is also interesting to be able to identify a fern which I believe belongs to Heer's genus *Hemitelites*, species of which occurs at Bovey Tracey and North Green-

[1] Dr. Scouler, in the first volume of the *Journ. Geol. Soc. of Dublin*, shows, from the evidence of Dr. Lindley, that these masses of wood were coniferous. The Rev. Dr. Macloskie, in a paper read at the Belfast Natural History Society, February 14, 1872, stated that they belong to the Cupressaceæ, and probably to the genus Sequoia, a coniferous tree (of which the great Wellingtonia of California is a living example, there being but two existing species, Sequoia sempervirens and S. gigantea, both natives of California) frequent in the Miocene of the Antrim basalt, and also in the accompanying ironstone nodules.

land, and to show that in all probability the fern named by Edward Forbes *Filicites Hebridicus* also belongs to the same genus.

LIST OF SPECIES.—NORTH OF IRELAND.

CRYPTOGAMÆ. *Fungi.*	
Sphæria concentrica (Massalonga Flor. Senégalliese)	Sandy Bay, Lough Neagh.
Filices.	
Hemitelites Frazeri, n. s. (Baily)	„ „
CONIFERÆ. Order *Cupressinæ.*	
Cupressites McHenrici (Baily), 'Journal Geol. Soc. Lond.' vol. xxv. pl. 15	Ballypalady, co. Antrim.
Order *Abietinæ.*	
Sequoia Du Noyeri (Baily), 'Journal Geol. Soc. Lond.' vol. xxv. pl. 15, f. 4	Ballypalady and Glenarm.
Sequoia Conttsiæ (Heer)	Sandy Bay, Lough Neagh, Bovey Tracey, N. Greenland, Baltic shores.
Pinus Plutoni (Baily), 'Journal Geol. Soc. Lond.' vol. xxv. pl. 15, f. 1	Ballypalady.
Pinus sp.	„
Fam. *Taxinæ.*	
Torellia sp.	„
MONOCOTYLEDONES.	
Fam. *Gramineæ.*	
Phragmites Œningensis (Ad. Brong.).	Ballypalady (Œningen, N. Greenland, Spitzbergen).
„ sp.	Ballypalady.
Poacites sp.	„
Iridæ.	
Iris latifolia? (Heer)	„ Spitz. Baltic.
DICOTYLEDONES.	
Fam. *Salicinæ.*	
Populus sp.	Ballypalady.
Betulaceæ.	
Alnus Kefersteini? Goepp	„ and Baltic.
Cupuliferæ.	
Corylus sp.	Lough Neagh and Glenarm.
? Fagus sp.	Ballypalady.
Quercus sp.	Glenarm.
Moreæ.	
Platanus Guillelmæ, Goepp	Glenarm, Œningen, N. Greenland.
Aceraceæ.	
Acer sp.	Glenarm.
Ericaceæ.	
Andromeda sp.	Ballypalady.
Caprifoliaceæ.	
Viburnum Whymperi (Heer)	Ballypalady, Spitz. and N. Greenland.
Araliaceæ.	
Nyssa ornithobroma (Heer)	Glenalvy river, near Lough Neagh, N. Greenland.
Menispermaceæ?	
McClintockia Lyalli (Heer)	Glenarm, N. Greenland.
„ trinerva (Heer)	Glenarm and Ballypalady, N. Greenland.
Rhamneæ.	
Rhamnus sp.	Ballypalady and Glenarm.
Juglandeæ.	
Juglans acuminata? (A. Braun).	Ballypalady, Œningen, and N. Greenland.

Report of the Committee, consisting of the Rev. H. T. Barnes-Lawrence, Mr. Spence Bate, Mr. H. E. Dresser (*Secretary*), Mr. J. E. Harting, Dr. Gwyn Jeffreys, Mr. J. G. Shaw Lefevre, M.P., Professor Newton, *and the* Rev. Canon Tristram, *appointed by the Council, for the purpose of inquiring into the possibility of establishing a Close Time for the Protection of Indigenous Animals.*

Your Committee has gratefully to acknowledge the resolution of the Council of the Association, whereby your Committee has been not only reappointed but also instructed to report to the Council in case of any action being required. Your Committee begs leave to state that no such emergency as was provided for by this instruction has arisen since the presentation of its last Report. Notwithstanding complaints that are occasionally heard, your Committee believes that public opinion continues strongly in favour of the close time principle, as applied to indigenous animals; and on the part of Her Majesty's Government no steps have been taken to carry out the recommendations of the Scottish Herring Fishery Commissioners, upon which your Committee deemed it its duty to animadvert last year. The Bird Preservation Acts, though doubtless evaded in some places, in general appear to work well, and to be enforced without difficulty when occasion requires. Having regard to future contingencies, your Committee ventures to solicit its reappointment with the instructions as to reporting to the Council in case of emergency.

Report of Committee, consisting of Mr. C. Spence Bate *and* Mr. J. Brooking Rowe, *appointed for the purpose of Exploring the Marine Zoology of Devon and Cornwall.*

The exceptionally severe weather during the past winter and spring has prevented the Committee carrying on the intended investigations, and, although some facts of interest have been noted, it is not prepared to report this year.

It therefore asks that it may be re-appointed, and that the grant may be continued.

Report of the Committee, consisting of Dr. M. Foster, Professor Rolleston, Mr. Dew-Smith (*Secretary*), Professor Huxley, Dr. Carpenter, Dr. Gwyn Jeffreys, Mr. Sclater, Mr. F. M. Balfour, Sir C. Wyville Thomson, *and* Professor Ray Lankester, *appointed for the purpose of arranging for the occupation of a Table at the Zoological Station at Naples.*

Since we submitted our last Report to the Association, the Zoological Station at Naples has continued to be successful in providing opportunity and appliances for naturalists studying the various forms of marine animals and plants. From September 1, 1878, to the end of July, 1879,

twenty-six naturalists have occupied the tables at the Institution. A list of their names and the time of stay will be found appended. During the same period, packages of specimens have been forwarded to fifty-one different naturalists and institutions. A list of these is also appended.

Recently a new department has been added to the Station. Through this naturalists will be enabled to obtain mounted specimens of microscopic animals, viz., sections of embryos of all kinds of fishes, &c., preparations of larvæ or other animals too small for being sent in alcohol or other preservative solutions. Next year a catalogue of these specimens will be published, and the Station will be prepared to send the specimens to any naturalist requiring them.

Trials of diving by means of the new Scaphander apparatus have also recently been made with very satisfactory results.

The aquarium of the Station is being in part reconstructed, with some important new features, viz., moveable rockwork, for saving and examining the different animals which thrive by themselves on these rocks. This will enable statistical notes to be established on the growth of these animals, and on such changes as may occur by changing their habitat, inasmuch as these rocks may be replaced in the sea at different depths.

The following monographs are in preparation by workers in the Station:—Ctenophoræ, Fierafer, Balanoglossus, Sipunculoidæ, Capitellidæ, Planariæ, Nemertineæ, Pycnogonidæ, Caprillidæ, and on several families of Algæ.

Three parts of the 'Mittheilungen aus der Zoologischen Station zu Neapel, zugleich ein Repertorium für Mittelmeerkunde' have been published, containing sixteen papers illustrated with many very carefully executed plates. Further parts are in active preparation.

It is, moreover, intended to publish the following works:—

'Fauna und Flora des Golfes von Neapel und der angrenzenden Meeresgebiete.' Folio. Yearly, 1 volume with 10–20 plates. The first volume is already in the press.

'Prodromus Faunæ Mediterraneæ.' A selection from the whole Zoological Literature of short Latin Diagnoses of the Animals found in the Mediterranean, with their habitats and local names.

'Zoologischer Jahresbericht.' This will contain short notices on the various memoirs and papers published in various countries on the subjects of Zoology, Development, and Comparative Anatomy. It is under the editorship of Professor Carus, with the assistance of four collaborateurs in different countries. One volume will appear yearly.

Two naturalists have occupied the table hired by the Association, viz., Mr. Walter Percy Sladen and Mr. Patrick Geddes. Mr. Sladen has sent in a report on his stay and his work, which is appended. In this report he proposes 'a means by which the table might be even more frequently occupied than it has been, and its sphere of utility thus extended, by suggesting to the consideration of the Committee that a further additional grant might be made by the Association, which would serve as a travelling fund. This might be apportioned in moieties say of 25*l.* to naturalists who desired to avail themselves of such assistance, and it is not improbable that many a student would by this means be enabled to participate in the advantages of the table at Naples, who might otherwise be deterred by the expense of the journey. The plan, extended or modified according to circumstances, is one adopted by several of the foreign bodies having tables at the Zoological Station.'

Mr. Patrick Geddes worked at the Station from February 26 to April 4. He 'repeated and extended certain observations on Echinoderm histology, and made experiments on *Bonellia viridis* and *Idotea viridis*, with a view of ascertaining the functions of their (supposed) chlorophyll.' The results of these studies are at present being published in the 'Archives de Zoologie Expérimentale' of M. de Lacaze Duthiers, viz., 'Etudes sur le Chlorophylle Animal;' 'Observations sur le Fluide Périviscéral des Oursins.'

Mr. Geddes also gained information on the working of the Station, in the hope (now realised) of helping to found a Zoological Station in Scotland. This station is now in working order at Stonehaven.

Mr. Arthur Wm. Waters, who worked at the Association table last year, intends again to apply for the appointment to occupy it, with a view of extending his researches on the Bryozoa of the Bay of Naples, already published in the 'Annals and Magazine of Natural History,' 1879.

Your Committee think that the above particulars are sufficiently encouraging to induce the Association to renew the grant of 75*l.* for the ensuing year.

Report on the Occupation of the Table, by Mr. W. Percy Sladen.

In conformity with the requirements of the Committee of the British Association appointed in connection with the Zoological Station at Naples, I beg to submit the following report concerning my occupancy of the table which I had the privilege of using.

In availing myself of the opportunity of working at Naples, the main object which I had in view was that of studying the pre-mature stages of the Echinodermata, and more especially the growth-phases which intervene between the period when the pluteus is resorbed and that at which the adult characters are developed—the range and significance of these changes being very important and remarkable throughout the group. In addition to this chief object, it is scarcely necessary to add that there were numerous points in the morphology of Echinoderms upon which, as a specialist, I was anxious to direct my attention, should time and opportunity permit.

I arrived in Naples on December 3, 1878, and remained there until February 17, 1879. During the greater portion of the time the weather was very inclement and stormy; in consequence of which the pelagic larval forms that I had hoped to have met with, by use of the surface-net, were driven to too great a depth, and owing to their microscopic proportions became thus altogether inaccessible. For this reason I was greatly disappointed in my expectations, and the material which I was able to obtain, in any way available for my projected investigations, was unfortunately very scanty; nevertheless several pre-mature forms of considerable interest were procured, and these I am hoping still further to elucidate, before the end of the year, by finding if possible the corresponding and intermediate stages on our own coasts, and which will then enable me to work out the development of at least one or two forms completely. I also endeavoured to contribute somewhat to this subject by means of the artificial fertilization of ova in several different families, but was always unsuccessful in keeping the *plutei* alive beyond a certain stage; whilst the fact that those thus raised in confinement were subject to very considerable abnormality in their development and present unnatural modifications which require much care and skill in elimination, in order to avoid error

in subsequent deductions, greatly diminishes the utility of such observations as a direct method of embryological study, although they are not without value as furnishing some indication of the plasticity inherent in a given form.

Better success rewarded what I may speak of as desultory investigations upon the general structure of Echinoderms. I may mention that I have in hand a contribution to the knowledge of *Pedicellariæ*, which I consider will throw light (if not entirely, at least in part) upon the functions of these obscure appendages. It was also my good fortune to discover in certain Asteroids an hitherto undescribed organ, most probably performing sensorial functions; an account of which I hope to publish shortly, as soon as time permits me to work up the material which I collected more exhaustively than I was able to do whilst staying at Naples. In addition to the above I am also hopeful of furnishing a communication upon the pre-mature anatomy of certain young Echinoderms, for which purpose I was able to preserve and bring back with me several very good series of specimens.

The general success and continually increasing prosperity of the Zoological Station at Naples are now so fully known from the reports and various publications emanating from the Institution itself, that it would be presumption on my part to offer any remarks in such a direction. I consider, however, that it is a duty for me to bear my individual testimony to the admirable arrangements which characterise the working of the Station, and which conduce so greatly to the comfort of naturalists engaged in studying there. The daily supply of fresh material, the tank and aquarium accommodation for keeping the same alive, are highly satisfactory, and leave little to be desired; whilst in the way of ordinary laboratory apparatus and re-agents no reasonable requirement is unprovided for.

I also desire to record my indebtedness for the genial kindness and the ever-ready assistance which I met with not only from Dr. Dohrn and the acting director Dr. Eisig, but the same friendly spirit of courtesy and help was accorded me without exception by every gentleman connected with the staff.

The utility of the Zoological Station being now so thoroughly established, and its reputation world-wide, it is unnecessary for me to allude to the fact, except to point out that the maintenance of such an undertaking is very costly, and that of necessity the results can only be continued by keeping up the funds. So much good work has already emanated from the Station at Naples that the Institution has a fair claim not only upon biological specialists, but on every one interested in the advancement of science. Upon such an argument, therefore, the Zoological Station is particularly worthy of the support of the British Association, even if its members were not (as many of them have already been), individual participants in the advantages which the Station provides; and on this ground I would strongly urge the continuance of the grant usually made by the Association.

I would further beg to propose a means by which the table might be even more frequently occupied than it has been, and its sphere of utility be thus extended, by suggesting to the consideration of the Committee that a further additional grant might be made by the Association, which would serve as a travelling fund. This might be apportioned in moieties say of 25*l.* to naturalists who desired to avail themselves of such assist-

ance, and it is not improbable that many a student would by this means be enabled to participate in the advantages of the table at Naples, who might otherwise be deterred by the expense of the journey. The plan, extended or modified according to circumstances, is one adopted by several of the foreign bodies having tables at the Zoological Station.

In conclusion I desire to express my cordial thanks to the Committee of the British Association for the privilege of using the table at their disposal.

The following tables are extracted from the 'Annual Report' issued by Dr. Dohrn:—

List of Naturalists to whom Specimens have been sent from August 1, 1878, to June 30, 1879.

				Lire
1878, August	1	Dr. K. Heider, Graz	Coelenteraten	10
„	1	L. C. Miall, Leeds	Fische, Mollusk., Würmer, Coelent.	80
„	4	Dr. Balfour, Cambridge	Selachier	20
„	5	Dr. Pieper, Olfen	Alle Classen	52
„	12	Prof. Mecznikoff, Odessa	„	340
„	12	Prof. v. Siebold, München	Muraeniden	65
Oct.	4	Prof. Ray Lankester, London	Moll., Crust., Würmer. Coel.	215
„	4	Progymnasium, Schlettstadt i. E.	Alle Classen	55
„	22	Prof. E. van Beneden, Lüttich	Coelenteraten	113
„	25	Museum, Oxford	Moll., Wür., Coel.	68
Nov.	5	Prof. Semper, Würzburg	Mollusken	40
„	5	Prof. Todaro, Rom	Salpen	50
„	6	Dr. Nagel, Tilsit	Alle Classen	59
„	21	T. Rier, Paris	Amphioxus	20
Dez.	6	Dr. H. Ludwig, Bremen	Echiniden	16
„	12	Prof. Schwalbe, Jena	Köpfe von Haien und Rochen	32
„	20	F. Balfour, Cambridge	Coelent., Würmer, Mollusk.	60
			Summa	1,295
1879, Jan.	9	Prof. Ehlers, Göttingen	Mollusk., Würmer., Coelent.	137
„	18	Prof. E. K. Hoffmann, Leiden	Selachier, Wür., Tunikaten	130
„	30	Realschule, Zweibrucken	Alle Classen	128
Feb.	3	Prof. Kühne, Heidelberg	Torpedo	28
„	10	Prof. Hoffmann, Leiden	Selachier, Embryonen	13
„	21	Realgymnasium, Gebweiler i. E.	Alle Classen	95
März	2	Zoolog. Museum, Palermo	Fische	41
„	17	Prof. Maly, Graz	Dolium	25
„	17	Prof. G. du Plessis, Lausanne	Hydromedusen	34
„	24	Prof. Ed. Brandt, St. Petersburg	Fische, Moll., Coelent.	112
„	17	Zoolog. Mus., Wien.	Fische	113
„	17	Zoolog. Inst., Graz	Spongien, Radiolarien, Foramf.	40
„	31	Prof. Benecke, Strassburg	Alle Classen	98
„	31	Naturwiss. Samml., Bremen	Moll., Würmer, Crust., Coelent.	153
„	31	Zool. Institut, Strassburg	Alle Classen	131
April	4	Prof. Cossar Ewart, Aberdeen	„	233
„	7	Prof. Kossmann, Heidelberg	Moll., Würm., Echin., Coelent.	87
„	7	H. Zehrfeld, Dresden	Alle Classen	80
„	10	Dr. H. Ludwig, Bremen	Echinodermen und Cephalopoden	94
„	15	Prof. Ehlers, Göttingen	Alle Classen	224
„	21	Grossh. Gymnasium, Constanz	„	21
			Carried forward	2,017

A List of the Naturalists who have worked at the Station from September 1, 1878, to the end of July 1879.

Nummer der Liste	Namen der Naturforscher	Staat oder Universität deren Tisch jeweils benutzt wurde	Zeitdauer des Aufenthaltes in der Station						Publicationen welche bis heute über die in der Station angestellten Untersuchungen erfolgt sind		Bemerkungen
			Anmeldung			Abmeldung			Titel der Schrift	Ort des Erscheinens	
			Tag	Monat	Jahr	Tag	Monat	Jahr			
99	Dr. Retzer	Würtemberg	2	Sept.	1878	26	Oct.	1878			
100	Dr. Albrecht	Hamburg	25	„	„	10	„	„			
101	Dr. v. Fehring	Baiern	23	Oct.	„	9	April	1879			
102	Dr. Lang	Schweiz	26	„	„	1	Juni	„			
103	Dr. Hubrecht	Holland	14	Nov.	„	17	Mai	„			
104	Mr. Percy Sladen	British Association	3	Dez.	„	16	Feb.	„			
105	Dr. Vaghante	Italien	1	Jan.	1879						
106	Dr. de la Valle	„	1	„	„						
107	Mr. Haddon	Cambridge	6	Feb.	„	14	Juni	„			
108	Dr. Geddes	British Association	26	„	„	4	April	„			
109	Prof. Graf Solms-Lunbach	Strassburg	3	März	„	9	Juli	„			
110	Prof. Owsjanikoff	Russland	4	„	„	25	Mai	„			
111	Dr. Andres	Italien	4	„	„						
112	Dr. Berthold	Preussen	9	„	„						
113	Dr. Solger	„	10	„	„	21	April	„			
114	Dr. Keller	Schweiz	10	„	„	19	„	„	Zur Entwickelungsgeschichte	Zoologischer Anzeiger, Nr. 30, Jahrgang 1879	
115	Prof. Selenka	Baiern	13	„	„	24	„	„	Keimblätter und Organanlage bei Echiniden	Sitz. Ber. Phys. Med. Soc., Erlangen, 1879	
116	Oberlehrer Brugger	Baden	23	„	„	22	„	„			
117	Prof. O. Hertwig	Sachsen	15	April	„	11	Mai	„			
118	Prof. R. Hertwig	Berliner Academie	15	„	„	4	„	„			
119	Prof. v. Koch	Hessen-Darmstadt	10	Mai	„	19	Juni	„			
120	Dr. v. Kennel	Baiern	14	Juni	„						
121	Dr. Ussov	Russland	28	„	„						
122	C. de Merejkowsky	„	28	„	„						
123	Prof. Todaro	Italien	18	Juli	„						
124	Prof. Emery	„	29	„	„						

List of Naturalists, &c.—*continued.*

				Lire
			Brought forward . . .	2,017
April	21	Dr. Keller, Zürich . . .	Coelenteraten . . .	110
„	29	Prof. Kossmann, Heidelberg .	Physalia	30
Mai	1	K. Puls, Gent	Spong., Anthoz. . .	196
„	6	Prof. van Beneden, Lüttich .	Alle Classen . . .	278
„	11	Prof. Todaro, Rom . . .	Salpen	23
„	20	Dr. Hubrecht, Leiden . .	Fische	135
„	21	Anatom. Institut, Halle . .	Mollusk., Würm., Crust., Coelent. . . .	47
„	21	S. Brogi, Siena	Alle Classen . . .	33
„	24	Prof. Reitimeyer, Basel . .	Fische, Coelent. . .	147
Juni	20	Prof. Ray Lankester, London .	Eier von Cephalop. .	5
„	20	Prof. Berlin, Amsterdam . .	Fische, Mollusk., Würm., Coelent. . . .	125
„	20	Prof. Harting, Utrecht . .	Alle Classen . . .	916
„	23	W. Kitchin Parker, London .	Embryonen von Hippocampus	17
			Summa . . .	4,079

	Lire
Einnahmen im Jahre 1876	3,194
„ „ 1877	2,459
„ 1878	3,175
„ 1879 (Jan. 1—Juni 30) .	4,079

Report of the Committee, consisting of Major-General Lane Fox, Mr. William James Knowles, Dr. A. Leith Adams, *and the* Rev. Dr. Grainger, *for the purpose of conducting Excavations at Portstewart, and elsewhere in the North of Ireland. Drawn up by* Mr. Knowles (*Secretary*).

The present report records a continuation of work hitherto carried on by the Secretary of this Committee, on the subject of which several papers have been read by him at previous meetings of the British Association. Up till the meeting of last year the work was chiefly confined to surface exploration. Several large pits had been found among the sand hills at Portstewart, and other places along the northern coast of Ireland, to contain large quantities of flint implements, hammer-stones, cores, and flakes, mixed up with numerous broken and split bones and teeth, which were supposed to be the remains of animals which had been used as food by the flint workers. It required very little attention and study to perceive that the pits had been excavated within a comparatively recent period, that the wind had but lately removed the sand which had previously filled the hollows, and left the flints and other objects in the bottom, because they were too heavy to be blown away. These objects had evidently been previously imbedded in a layer of dark colour, remains of which were visible all around the sides of the pits, but on which there remains in places undisturbed a covering of sand varying in thickness from 10 to 50 feet. This layer has been generally cut through where pits are formed, and the remains found in the bottom have gradually reached a somewhat lower level than the place formerly occupied by

them, but in some cases the layer has resisted denudation and forms a sort of platform. In other places, where the layer dips, it may appear at the surface as an outcrop, or form a diminutive escarpment.

The space over which this layer spreads has not been accurately made out. It is not, however, co-extensive with the sandhills, which can be explained by supposing that other hills of sand have been heaped up since the time the manufacturers of flint implements lived there. At Portstewart and the opposite side of the river Bann this layer may be estimated with safety to spread over two square miles, all of which, with the pits already mentioned, has a covering of sand, not of a shifting nature, but of a permanent kind, because covered and protected by a close crop of vegetation. Although the sandhills now reach to the very mouth of the Bann, the black layer does not extend so far. It has been observed that from $1\frac{1}{2}$ to 2 miles from the river's mouth, though we have the same kind of sandhills and pits as we have farther inland, there are no such black layers or flint objects to be found on either side of the river, which would lead to the conclusion that at the time this black layer was an exposed surface the river Bann emptied into the sea about two miles farther inland than it does at present.

The operations of the past year at Portstewart have been chiefly confined to digging over the exposed portions of the black layer, though a small amount of excavation has been made into the black layer which is still beneath the sandy covering.

In one spot of exposed layer, measuring three square yards, one scraper, one core, and several flakes were obtained, but no animal remains. Another small piece of layer, of similar extent in a different pit, yielded several flakes and a great many fragments of pottery. Two small pieces were ornamented. These were parts of the rim of a vessel, and the ornamentation was longitudinal lines with cross striation, resembling what would be produced if the milled edge of a shilling were rolled along soft clay. No animal remains were found. Another small piece of exposed layer in a third pit yielded a little nest of eleven small scrapers, but no other remains.

In one of the largest pits, at a place where the edge of the dark layer is seen cropping out under 50 feet of sand, and where bones, both cut and split, and also teeth had been found in abundance lying exposed, a portion of the covering was removed, laying bare about 20 square yards of the dark layer, which was carefully dug over. A considerable quantity of broken and split bones and teeth were obtained, chiefly those of ox and deer, two flint flakes, two hammer-stones, one of which, in addition to the hammered ends, had its sides also hammered, as if an attempt had been made to form an oval tool-stone. The depression seems to have been formed by repeated blows with another stone being struck on the same spot. Also a small stone, four inches long, rather square in section, having one end sloped away by rubbing. Mixed up with these in the layer were small pieces of charred wood and many broken and rounded stones, and also a few shells, chiefly *Patella*. It was near this place that some bone implements, a small ornament, and cut bones were found on the surface, and which have been described in previous papers. One of the persons employed, in the absence of your secretary, dug out of the layer at this place a portion of the antler of a red deer having several tines sawn off. It is the upper half of the antler, and one long tine remains projecting at the upper extremity in such a way that a sort of pick is

formed. In the centre of this pit, and only a few yards from the place where the bones have been found so plentifully, a very large quantity of flint scrapers, several arrowheads, knives, hammer-stones, and cores were obtained, all mixed up with an immense quantity of flint flakes and chips.

Castlerock.—The Bann separates this place from Portstewart. Sandhills containing similar implements are found here. On a recent visit of the Ballymena Naturalists' Field Club, accompanied by the Rev. Dr. Grainger, M.R.I.A., Vice-President, and also a member of this Committee, as many as 200 flint implements of various kinds were obtained, but the layer where experimented on yielded rather poor results.

Whitepark Bay, Ballintoy.—There are sandhills at this place somewhat similar to those at Portstewart, and there is also the dark-coloured implement-bearing layer, but the portion richest in remains lies along the top of a bank quite close to the sea and about 30 feet above sea level. The sand has been removed from above the layer on the top of this bank for about a quarter of a mile in length by a few yards in breadth, leaving the comparatively solid floor of blackish matter undisturbed in many spots. About 30 square yards of the richest part of this floor was dug over, and it yielded a great quantity of flakes, fifty-three scrapers, two large triangular-shaped flints, one of which is dressed at the pointed end after the manner of a scraper, a bored stone or whorl, the thick end of an antler of a red deer, having a hole bored through near its base, the half of an oval tool-stone, cores, several hammer-stones, one showing work on the sides as well as at the ends, a bone pin, a bone needle, several pieces of pottery, showing handsome ornamentation, an ochreous stone, which has been much rubbed and scraped, and a small portion of a similar stone. There were also a few shells and a great quantity of teeth and bones mixed up with the implements. The long bones were all broken and split. The bones and teeth corresponded very closely with those previously found lying exposed on the surface, and which Professor A. Leith Adams found to contain those of man, horse, ox, wolf or dog, fox, deer, and hog.

The hole in the antler is oval, and gets narrower towards the centre, like the holes in many stone hammers. At the surface it is $1\frac{1}{2}$ inches in diameter longitudinally and $1\frac{1}{4}$ inches across. In the centre of the hole the diameters are nearly 1 inch and $\frac{3}{4}$ inch respectively.

The hole in the whorl is comparatively wide at both surfaces of the stone, about $\frac{5}{8}$ inches in diameter, and gets narrower towards the centre. The outer and wider portions have a battered appearance, as if those parts had been formed by hammering, but the central portion has a ringed appearance, some parts being wider than others. This central part may have been bored by means of a rotating stick and sharp sand and water. The wider portions would be formed when the end of the stick had become slightly broader by wear, and the narrower portions at the times when it was newly trimmed.

Dundrum, County Down.—There are extensive sandhills at this place, which were lately examined by the secretary of this committee. Frequent visits have been made to this place by the Belfast Naturalists' Field Club and by Mr. Gray, who is president of the society for the present year, and it has been described as one of several places where flint flakes and scrapers are to be found. It was not, therefore, expected that any quantity of remains would be obtained, and the chief object in going

was to ascertain if there were the same implement-bearing layers here as at Portstewart and Ballintoy. Mr. Knowles visited Dundrum on two occasions alone in July, and once in August, accompanied by the Rev. Dr. Grainger. On these three occasions 1122 manufactured objects were obtained, viz. 1013 scrapers, forty-one arrow heads, forty-six scrapers with concave scraping edge, eighteen dressed flakes and borers, one stone, somewhat of the nature of an oval tool-stone, one of those oval stones with a small track on each side, described in the Catalogue of the Royal Irish Academy as sling-stones, one stone like a tool-stone, but having only one side indented, and also a small serpentine bead of similar form, but slightly larger than those found at Portstewart, which have been described in previous papers. Here, as at Portstewart and Ballintoy, there are sometimes several black layers to be seen, and it has been remarked that generally only one of those layers contains flints. Sometimes a large pit has a pillar of sand standing up capped by a black layer, or perhaps there may be a large table-like mass, capped in a similar way. The majority of the objects described were found exposed, many showing evidence of having only recently dropped from the layer, but in places where excavation was tried as an experiment, scrapers were found, as at the places previously mentioned. In one place the flint objects were found close to the edge of a layer, where they had been set free by denudation; while in another layer, higher up on the side of the same pit, there was no trace of implements, though full of rounded and broken stones, and at first sight presenting a very similar appearance to the layer below.

The scrapers are mostly all of very small size. Hundreds of them are not larger than the finger-nail, and in almost every case, no matter how small, there is found remaining a portion of the original crust of the pebble from which the scraper has been formed. Some of them are very neatly dressed, and are beautiful objects.

About one-third of the arrowheads are perfect and of great beauty. In one case a broken one has had the broken edge dressed and formed into a scraper.

The scrapers with concave scraping edge were no doubt used for scraping cylindrical objects. They are nearly all perfect, and it was remarked about them, as about the arrowheads, that where one was found several more might be expected. These hollow scrapers were found chiefly in three spots, and about a dozen were obtained in each place. The other objects are chiefly flakes, dressed over the back or along the edges, and having a flat side undressed. The contrast between this place and Ballintoy is very marked. Here everything points to a scarcity of material, and comparatively few flakes are left undressed. Even other rocks are found split up into flakes, and two beautiful flakes of a rock crystal were picked up. At Ballintoy and some other places, on the other hand, there seems to have been a perfect waste of material, and every object is of large size.

The stone which bears some resemblance to a tool-stone is rather irregular in form, and the hollows are not equal in size nor exactly opposite each other, but the hollows communicate by a very narrow opening.

The so-called sling-stone was picked up by Dr. Grainger. He was walking slowly along near the edge of a large pit and found it lying among a few other pebbles, but it cannot be said that any flint objects were in association with it. At the distance of a few yards, however,

towards the centre of the same pit, ten or twelve scrapers with concave edge, several other scrapers, and a beautiful stemmed arrowhead, were found.

The bead was also found by Dr. Grainger, and some scrapers were found quite near to it. It is rounded on one side and flat on the other, and similar in every respect, except size, to those found at Portstewart.

Several hammer-stones were found having their sides as well as ends hammered, sometimes hollows being formed, bearing a resemblance to those on the sides of the oval tool-stones.

Animal remains were very scarce, only a few teeth were picked up, and these chiefly belonged to the horse, ox, and deer.

Report of the Anthropometric Committee, consisting of Dr. FARR, Dr. BEDDOE, Mr. BRABROOK (*Sec.*), Sir GEORGE CAMPBELL, Mr. F. P. FELLOWS, Major-Gen. LANE FOX, Mr. FRANCIS GALTON, Mr. PARK HARRISON, Mr. JAMES HEYWOOD, Mr. P. HALLETT, Professor LEONE LEVI, Sir RAWSON RAWSON, Professor ROLLESTON, and Mr. CHARLES ROBERTS.

[PLATES IX.—XII.]

THE Committee was appointed for the purpose of continuing the collection of observations on the systematic examination of heights, weights, &c., of human beings in the British Empire, and the publication of photographs of the typical races of the Empire. That any conclusions drawn from statistics thus collected may be trustworthy, it is obviously essential that as large an average of facts as possible should be obtained, and that the services of a large number of independent investigators should be enlisted. Having, in previous years, laid down the lines upon which observers should proceed, and prepared a circular of instructions, the attention of the Committee has been directed this year not so much towards any attempt to draw conclusions from the facts before them, as towards completing the collection of data, and obtaining the services of fresh observers in various quarters. They have endeavoured, wherever practicable, to induce persons in a position to collect anthropometric statistics, particularly those tending to establish a law of growth and development, to establish a system of periodical record, which from year to year will increase in value and interest. By this means, many difficult problems in relation to race, occupation, climate, culture, &c., may in due course be solved.

Considerable progress has been made by the Committee during the year in the collection of observations and in reducing the results to a tabular shape. No alteration has been made in the forms and instruments used, except that the capacity of the spirometer-bag has been increased, it being found that many persons in selected occupations exceeded the maximum capable of registry by the original instrument. The types for colour of hair have been seriously reconsidered, and the 'stenochromic' process approved—but as the process turned out not to be commercially available, no alteration in the existing book of types has been adopted.

Returns have been received from the following sources, containing the particulars undermentioned in respect of the number of individuals stated in each case:—

Sources	Birth-place, Origin, and Sex	Age, Height, and Weight	Colour of Hair and Eyes	Girth of Chest	Strength of Arm	Eye-sight
1. Cadets Royal Military College, Sandhurst	300	300	300	† 300	300	300
2. Boys at Westminster School	200	200	200	—	200	—
3. Students at Aberystwith	40	40	40	40	40	40
4. Boys at Christ's Hospital	—	1936	—	846	—	—
5. Medical Students	46	46	46	† 46	46	41
6. Felstead Grammar School	62	62	62	† 62	62	—
7. Men in Mr. Whiteley's employ	*242	242	—	—	242	—
8. Letter Sorters	—	1980	—	1180	—	—
9. Metropolitan Police	205	205	205	† 205	205	205
10. City Police (first instalment)	60	60	60	† 60	60	60
11. Metropolitan Fire Brigade	80	80	80	† 80	80	80
12. Jews	*140	140	140	140	—	—
13. „ (another source)	20	20	20	20	—	—
14. Industrial Classes	82	82	42	42	—	6
15. Workmen of Messrs. Howard	67	67	66	† 65	62	19
16. Workmen (Dr. Bain)	28	28	28	28	28	—
17. Scotland, various occupations	20	20	20	20	—	—
18. Weavers	*120	120	—	† 120	120	—
Rifle Volunteers.						
19. Northumberland	200	200	200	200	—	—
20. Cumberland	40	40	40	40	—	—
21. Cornwall	110	110	110	110	—	—
22. Somerset	155	155	155	155	—	—
23. Essex	89	89	89	89	13	14
24. Suffolk	135	135	135	135	—	—
25. Kent	* 90	90	—	†	90	—
26. Royal Surrey Militia	459	459	459	† 459	459	459
27. Volunteers and Militia, Surrey	124	124	124	† 124	124	124
28. Recruits	*100	100	100	100	—	—
29. „	32	32	—	32	—	—
30. „	* 79	79	62	79	—	—
31. „	*190	190	—	190	—	—
32. „	*100	100	—	100	—	—
33. „	*218	218	88	218	—	—
34. „	128	128	108	128	—	20
35. „	*260	356	—	96	—	—
36. „	200	200	200	200	—	—
37. „	199	199	199	199	—	—
38. Soldiers	20	20	20	20	—	—
39. H.M.S. *Fisguard*	* 59	59	59	59	—	—
Industrial Schools.						
40. Newcastle	*150	150	150	150	—	—
41. Birmingham	84	84	84	84	—	—
42. Greenock	*100	100	100	100	—	—
43. Park Row (Bristol)	* 70	70	70	—	—	—
44. St. James (Bristol)	70	70	70	—	—	—
45. Sale, near Manchester, Girls'	* 80	80	80	—	—	—
46. Criminals	—	2480	—	—	—	—
	5254	11745	4011	6321	2131	1368

To which are to be added the very extensive observations collected by Mr. Roberts, which will be referred to at length in a subsequent part of this Report. In those marked * particulars of race and origin have not been in all cases given; on the other hand, in those marked † the important particular of breathing capacity has also been observed.

The Committee are thus already in possession of nearly 12,000 original observations on the main question of weight and height in relation to age, in addition to the 50,000 collected by Mr. Roberts, and they have information of returns being in preparation from many other sources.

The following tables exhibit the general result of the returns of height and weight, and the relations between them :—

AVERAGE HEIGHT.

Age	Militia		Recruits		Metropolitan Police		Metropolitan Fire Brigade		Mr. Whiteley's Shopmen		Letter Sorters, &c., General Post Office		Messrs. Howard's Workmen	
	Number of Observations	Average Height in Inches	Number of Observations	Average Height in Inches	Number of Observations	Average Height in Inches	Number of Observations	Average Height in Inches	Number of Observations	Average Height in Inches	Number of Observations	Average Height in Inches	Number of Observations	Average Height in Inches
12–	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13–	—	—	2	54·0	—	—	—	—	—	—	36	55·9	—	—
14–	1	55·0	6	55·7	—	—	—	—	—	—	503	60·3	—	—
15–	—	—	—	—	—	—	—	—	2	65·5	670	61·7	—	—
16–	4	64·5	1	60·5	—	—	—	—	8	65·1	275	63·9	1	64·5
17–	13	64·0	3	65·2	—	—	—	—	8	63·5	124	65·4	2	61·5
18–	35	64·7	37	65·8	—	—	—	—	8	66·8	98	65·4	3	69·2
19–	35	65·4	44	66·3	—	—	2	69·5	10	66·1	86	66·4	3	67·2
20–	34	65·3	29	66·5	1	71·5	1	69·5	21	67·3	30	66·4	4	66·3
21–	43	66·5	19	66·8	5	69·5	4	68·3	23	65·9	43	65·8	6	67·7
22–	38	65·5	15	67·4	7	69·2	4	67·8	21	67·3	19	67·1	6	68·2
23–	31	65·6	13	66·8	15	70·4	4	68·0	22	66·6	15	66·8	1	70·5
24–	22	66·3	21	67·7	18	69·8	3	66·5	21	66·6	17	66·6	1	64·5
25–	93	65·8	8	67·9	75	70·2	25	67·5	54	66·0	61	66·2	12	66·7
30–	48	66·1	2	69·5	41	71·0	16	68·2	22	67·0	2	65·0	12	66·1
35–	30	65·9	—	—	33	69·6	10	68·4	18	66·4	1	64·0	9	66·8
40–	15	66·9	—	—	7	69·6	9	67·3	1	66·5	—	—	3	65·2
45–	12	67·1	—	—	3	69·8	2	66·0	1	64·5	—	—	3	66·2
50–	3	69·0	—	—	—	—	—	—	1	70·5	—	—	1	68·5
55-60	2	69·5	—	—	—	—	—	—	1	72·5	—	—	—	—
All ages	459	65·8	200	66·1	205	70·2	80	67·9	242	66·4	1980	62·6	67	66·7
Average age	25·9		20·9		30·0		30·8		25·4		16·6		28·9	

NOTE.—If the comparison is limited to the ages between 20 and 35, the averages range as follows:—

Letter Sorters	64 to 67·1
Militia	65·3 „ 66·5
Mr. Whiteley's Men	65·9 „ 67·3
Messrs. Howard's Men	66·1 „ 70·5 (one case only)
Recruits	66·5 „ 69·5
Fire Brigade	66·5 „ 69·5 (one case only)
Police	69·2 „ 71·5 (one case only)

AVERAGE WEIGHT.

Age	Militia		Recruits		Metropolitan Police		Metropolitan Fire Brigade		Mr. Whiteley's Shopmen		Letter Sorters, &c., General Post Office		Messrs. Howard's Workmen	
	Number of Observations	Average Weight in Pounds	Number of Observations	Average Weight in Pounds	Number of Observations	Average Weight in Pounds	Number of Observations	Average Weight in Pounds	Number of Observations	Average Weight in Pounds	Number of Observations	Average Weight in Pounds	Number of Observations	Average Weight in Pounds
12–	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13–	—	—	2	77·5	—	—	—	—	—	—	36	74·7	—	—
14–	1	72·0	6	85·0	—	—	—	—	—	—	503	93·3	—	—
15–	—	—	—	—	—	—	—	—	2	127·5	670	100·5	—	—
16–	4	122·5	1	107·5	—	—	—	—	8	126·3	275	111·5	1	132·5
17–	13	119·4	3	110·8	—	—	—	—	8	113·1	124	120·5	2	122·7
18–	35	126·2	37	129·0	—	—	—	—	8	135·0	98	123·3	3	144·2
19–	35	136·3	44	135·8	—	—	2	155·0	10	137·5	86	128·7	3	129·2
20–	34	134·1	29	137·3	1	162·5	1	162·5	21	146·3	30	130·0	4	138·8
21–	43	137·6	19	141·4	5	163·5	4	155·0	23	139·5	43	127·6	6	141·7
22–	38	138·0	15	148·8	7	161·6	4	148·8	21	145·8	19	132·0	6	147·5
23–	31	133·8	13	142·5	15	172·2	4	156·3	22	146·4	15	136·5	1	157·5
24–	22	128·4	21	146·5	18	169·7	3	140·8	21	144·9	17	139·9	1	132·5
25–	93	140·5	8	145·0	75	173·6	25	155·1	54	146·0	61	137·7	12	147·5
30–	48	144·6	2	132·5	41	182·7	16	166·3	22	163·2	2	122·5	12	155·0
35–	30	138·2	—	—	33	183·6	10	169·0	18	158·3	1	117·0	9	161·4
40–	15	152·2	—	—	7	208·9	9	170·3	1	172·5	—	—	3	147·5
45–	12	145·0	—	—	3	209·2	2	167·5	1	157·5	—	—	3	140·8
50–	3	154·0	—	—	—	—	—	—	1	217·5	—	—	1	162·5
55–60	2	142·5	—	—	—	—	—	—	1	207·5	—	—	—	—
All ages	459	137·6	200	135·6	205	177·6	80	160·4	242	145·9	1980	106·4	67	147·6
Average age	25·9		20·9		30·0		30·8		25·4		16·6		28·9	

NOTE.—Taking, as before, the ages between 20 and 35, which affords means of comparison between all the columns, the diversity of weights in the various classes appears to be much greater than that of height, as follows:—

Letter Sorters	122·5 to 139·9
Militia	128·4 „ 144·6
Recruits	132·5 „ 148·8
Messrs. Howard's Men	132·5 „ 157·5
Mr. Whiteley's Men	139·5 „ 163·2
Fire Brigade	140·8 „ 166·3
Police	162·5 „ 182·7

RATIO OF WEIGHT TO HEIGHT.

Age	Militia		Recruits		Metropolitan Police		Metropolitan Fire Brigade		Mr. Whiteley's Shopmen		Letter Sorters, &c., General Post Office		Messrs. Howard's Workmen	
	Number of Observations	Ratio between Height and Weight*	Number of Observations	Ratio between Height and Weight*	Number of Observations	Ratio between Height and Weight*	Number of Observations	Ratio between Height and Weight*	Number of Observations	Ratio between Height and Weight*	Number of Observations	Ratio between Height and Weight*	Number of Observations	Ratio between Height and Weight*
12–	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13–	—	—	2	1·4	—	—	—	—	—	—	36	1·3	—	—
14–	1	1·3	6	1·5	—	—	—	—	—	—	503	1·5	—	—
15–	—	—	—	—	—	—	—	—	2	1·9	670	1·6	—	—
16–	4	1·9	1	1·8	—	—	—	—	8	1·9	275	1·7	1	2·1
17–	13	1·9	3	1·7	—	—	—	—	8	1·8	124	2·0	2	2·0
18–	35	2·0	37	2·0	—	—	—	—	8	2·0	98	1·9	3	2·1
19–	35	2·1	44	2·0	—	—	2	2·2	10	2·1	86	1·9	3	1·9
20–	34	2·1	29	2·1	1	2·3	1	2·3	21	2·2	30	2·0	4	2·1
21–	43	2·1	19	2·1	5	2·4	4	2·3	23	2·1	43	1·9	6	2·1
22–	38	2·1	15	2·2	7	2·3	4	2·2	21	2·2	19	2·0	6	2·2
23–	31	2·0	13	2·1	15	2·4	4	2·3	22	2 2	15	2·0	1	2·2
24–	22	1·9	21	2·2	18	2·3	3	2·1	21	2·2	17	2·1	1	2·1
25–	93	2·1	8	2·1	75	2·5	25	2·3	54	2·2	61	2·1	12	2·2
30–	48	2·2	2	1·9	41	2·6	16	2·4	22	2·4	2	1·9	12	2·3
35–	30	2·1	—	—	33	2·6	10	2·5	18	2·4	1	1·8	9	2·4
40–	15	2·3	—	—	7	3·0	9	2·5	1	2·6	—	—	3	2·3
45–	12	2·2	—	—	3	3·0	2	2·5	1	2·4	—	—	3	2·1
50–	3	2·2	—	—	—	—	—	—	1	3·1	—	—	1	2·4
55–60	2	2·1	—	—	—	—	—	—	1	2·7	—	—	—	—
All ages	459	2·1	200	2·1	205	2·5	80	2·4	242	2·2	1980	1·7	67	2·2
Average age	25·9		20·9		30·0		30·8		25·4		16·6		28·9	

* Viz., number of pounds in weight to an inch in height.

NOTE.—Taking, as before, the ages between 20 and 35, the average ratios are as follows:—

Letter Sorters	1·9 to 2·1
Recruits and Militia	1·9 „ 2·2
Messrs. Howard's Men	2·1 „ 2·3
Mr. Whiteley's Men and the Fire Brigade	2·1 „ 2·4
Police	2·3 „ 2·6

HEIGHT.

Age last Birthday	Westminster School, Dean's Yard		Industrial Schools							
			Newcastle		Shustoke, Birmingham		Greenock		Sale (Females)	
	Number of Observations	Average Height in Inches	Number of Observations	Average Height in Inches	Number of Observations	Average Height in Inches	Number of Observations	Average Height in Inches	Number of Observations	Average Height in Inches
5	—	—	1	41·5	—	—	—	—	—	—
6	—	—	2	43·5	—	—	—	—	—	—
7	—	—	3	43·8	—	—	2	43·5	1	44·5
8	—	—	10	45·7	3	45·5	2	46·0	—	—
9	—	—	11	47·5	5	49·1	6	48·5	5	47·7
10	2	53·0	27	47·8	18	49·0	7	49·2	6	49·7
11	7	55·4	22	49·7	13	49·0	11	51·5	17	50·9
12	15	57·8	26	51·4	15	51·6	24	52·1	10	52·7
13	20	59·7	17	51·8	11	52·6	29	53·5	17	54·7
14	48	61·3	18	53·9	5	54·5	16	55·7	14	57·4
15	39	64·8	12	57·8	11	55·0	2	56·5	9	58·5
16	43	66·5	1	56·5	3	55·5	1	59·5	1	59·5
17	18	67·8	—	—	—	—	—	—	—	—
18	8	67·5	—	—	—	—	—	—	—	—
All ages	200	63	150	50·4	84	51·2	100	52·5	80	53·7
Average age	15·2		11·9		12·4		12·6		12·8	

NOTE.—It will be observed, upon comparison of the columns relating to Industrial Schools, that the Sale school, which consists of girls, has the advantage in height, nearly throughout, over the three schools which consist of boys.

WEIGHT.

Age last Birthday	Westminster School, Dean's Yard		Industrial Schools							
			Newcastle		Shustoke, Birmingham		Greenock		Sale (Females)	
	Number of Observations	Average Weight in Pounds	Number of Observations	Average Weight in Pounds	Number of Observations	Average Weight in Pounds	Number of Observations	Average Weight in Pounds	Number of Observations	Average Weight in Pounds
5	—	—	1	42·5	—	—	—	—	—	—
6	—	—	2	42·5	—	—	—	—	—	—
7	—	—	3	47·5	—	—	2	50·0	1	37·5
8	—	—	10	51·5	3	54·2	2	57·5	—	—
9	—	—	11	53·4	5	61·5	6	64·2	5	50·5
10	2	69·0	25	55·3	18	60·0	7	66·8	6	56·7
11	7	68·4	22	62·0	13	64·8	11	71·6	17	59·6
12	15	78·1	26	64·8	15	69·8	24	77·5	10	66·0
13	20	86·2	17	69·6	11	67·8	29	80·3	17	76·6
14	48	95·3	18	74·2	5	79·5	16	90·0	14	88·6
15	39	111·5	12	92·5	11	95·7	2	90·0	9	95·8
16	43	124·2	1	82·5	3	97·5	1	112·5	1	87·5
17	18	129·6	—	—	—	—	—	—	—	—
18	8	138·1	—	—	—	—	—	—	—	—
All ages	200	106	148	64·3	84	70·6	100	77·8	80	72·4
Average age	15·2		11·9		12·4		12·6		12·8	

NOTE.—The Girls' Industrial School seems to have an advantage in weight over the Boys' Schools (Greenock excepted), but not equal to the advantage in height.

RATIO OF WEIGHT TO HEIGHT.

Age	Westminster School, Dean's Yard		Industrial Schools.							
			Newcastle		Shustoke, Birmingham		Greenock		Sale (Females)	
	Number of observations	Ratio between height and weight*	Number of observations	Ratio between height and weight*	Number of observations	Ratio between height and weight*	Number of observations	Ratio between height and weight*	Number of observations	Ratio between height and weight*
5	—	—	1	1·0	—	—	—	—	—	—
6	—	—	2	1·0	—	—	—	—	—	—
7	—	—	3	1·1	—	—	2	1·1	1	0·8
8	—	—	10	1·1	3	1·2	2	1·3	—	—
9	—	—	11	1·1	5	1·3	6	1·3	5	1·1
10	2	1·3	27	1·2	18	1·2	7	1·4	6	1·1
11	7	1·2	22	1·2	13	1·3	11	1·4	17	1·2
12	15	1·4	26	1·3	15	1·4	24	1·5	10	1·3
13	20	1·4	17	1·3	11	1·3	29	1·5	17	1·4
14	48	1·6	18	1·4	5	1·5	16	1·6	14	1·5
15	39	1·7	12	1·6	11	1·7	2	1·6	9	1·6
16	43	1·9	1	1·5	3	1·8	1	1·9	1	1·5
17	18	1·9	—	—	—	—	—	—	—	—
18	8	2·0	—	—	—	—	—	—	—	—
All ages .	200	1·7	150	1·3	84	1·4	100	1·5	80	1·3
Average age	15·2 years		11·9 years		12·4 years		12·6 years		12·8 years	

* Number of pounds in weight to an inch in height.

NOTE.—Taking the ages 12 and 13 as those which afford the largest number for comparison, it would seem that the ratio between height and weight does not differ largely among these very diverse classes.

The returns relating to Christ's Hospital have been abstracted for the Committee by Sir Rawson W. Rawson, for each month of age as shown by the subjoined tables:—

TABLE I.—Statement of the *Height*, without shoes, of boys in the School of Christ's Hospital, showing the average, maximum, and minimum at each month, quarter, and year of age, between 9 and 16.

Age in Years and Months	No. of Observations	Height in Inches and Decimals						
		Monthly			Quarterly		Yearly	
		Average	Maximum	Minimum	No. of Observations	Average	No. of Observations	Average
9 0	1	47·4	—	—	—	—	—	—
1	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—
4	1	49·1	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—
6	3	50·1	52·4	48·4				
7	3	51·2	52·5	50	9	51·2		
8	3	52·3	57	49				
9	2	50·7	51	50·4			22	50·8
10	1	51·2	—	—	13	50·6		
11	10	50·5	52·3	49·2				
	Average of Monthly Averages		53	49·4				
10 0	10	51·9	54·5	48·4				
1	8	51·6	54·5	49·6	27	51·7		
2	9	51·4	55·2	49				
3	17	51·3	54·6	47·6				
4	14	51·3	56	48·4	44	51·5		
5	13	52·2	54·1	49				
6	21	52·2	54·4	49·4			210	52·2
7	13	52·4	55·2	47·6	64	52·5		
8	30	52·9	56·6	49·4				
9	24	52·3	57	48·5				
10	27	52·8	56·2	47·4	75	52·5		
11	24	52·3	55·7	49·4				
	Average of Monthly Averages		55·3	49·1				
11 0	24	52·6	57	49				
1	24	52·9	56	50·3	83	52·6		
2	35	52·5	56	49·1				
3	36	52·9	60·4	47·6				
4	29	54	59·4	49·1	102	53·2		
5	37	53·1	60·2	49				
6	33	53·1	57	50·3			392	53·7
7	38	53·4	58·7	47·6	102	53·6		
8	31	54·3	59	48·2				
9	24	54·2	59·4	50·3				
10	37	54·4	60·2	47·4	105	54·2		
11	44	54·2	59	50·6				
	Average of Monthly Averages		58·4	49·1				

TABLE I.—STATEMENT OF THE HEIGHT, &c.—*continued.*

Age in Years and Months	No. of Observations	Height in Inches and Decimals						
		Monthly			Quarterly		Yearly	
		Average	Maximum	Minimum	No. of Observations	Average	No. of Observations	Average
12 0	33	54·2	58·5	48·4				
1	37	54	60·1	51·4	105	54·2		
2	35	54·5	58	51				
3	31	54·6	58·6	51				
4	51	54·6	59·4	49	115	54·6		
5	33	54·9	59	50			410	54·7
6	47	54·9	58·5	51·5				
7	38	54·7	58·4	49·2	118	54·6		
8	33	54·2	59·4	50·3				
9	22	55·1	57·5	52				
10	19	54·9	59·7	49·4	72	55·6		
11	31	55·9	61	50·6				
	Average of Monthly Averages		59·1	50·3				
13 0	21	57	62	51·7				
1	39	56·2	61·5	49	91	56·2		
2	31	55·9	62·4	51·4				
3	29	56·9	61	51·4				
4	34	56·5	65·7	52	98	56·4		
5	35	56	61·5	51			353	56·7
6	34	56·6	61·4	50·1				
7	35	56·7	62·2	51·4	95	56·9		
8	26	57·8	63	54·2				
9	20	56·5	59·4	52·3				
10	17	57·5	60·4	53·4	69	57·3		
11	32	57·7	64·4	48				
	Average of Monthly Averages		62·1	51·3				
14 0	26	57·8	62·4	53				
1	28	58·3	64·4	50·1	83	58·2		
2	29	58·6	65·5	53·1				
3	22	59·2	64·2	53·7				
4	27	57·2	63	53·2	80	58·4		
5	31	58·9	63·4	52·6			291	58·6
6	22	58·5	65·3	52				
7	25	58·6	62·4	53·2	68	59·2		
8	21	60·4	65·7	55				
9	18	58·7	63·4	53				
10	13	59·3	64	56	60	58·6		
11	29	58·3	66·4	54				
	Average of Monthly Averages		64·2	53·2				

TABLE I.—STATEMENT OF THE HEIGHT, &c.—*continued.*

Age in Years and Months	No. of Observations	Height in Inches and Decimals						
		Monthly			Quarterly		Yearly	
		Average	Maximum	Minimum	No. of Observations	Average	No. of Observations	Average
15 0	29	60·1	66	51·2				
1	33	60·4	65·2	53·4	91	60·4		
2	29	60·6	67·4	54·1				
3	17	61·4	66·3	54·6				
4	25	61·8	66·2	57·2	54	61·6		
5	12	61·3	66·4	57·4			236	61·3
6	14	61·9	66	55				
7	13	60·2	65	57·1	42	61·3		
8	15	61·6	67	57				
9	22	62·6	67·4	55·7				
10	16	62·8	68·2	56·4	49	62·8		
11	11	63·4	69·4	57·4				
	Average of Monthly Averages		66·7	55·6				
16 0	8	63·4	67·4	56·6				
1	4	62·9	68·2	60				
2	—	—	—	—				
3	2	64·2	66·2	62·2	17	63·4		
4	1	63·6	—	—				
5	2	63·7	67·1	63·4				
6	—	—	—	—			22	62·8
7	—	—	—	—				
8	2	59	59·5	56·8				
9	1	61·2	—	—				
10	1	62·4	—	—	5	61·3		
11	1	65	—	—				
	Average of Monthly Averages		65·7	60·1				

TABLE II.—Statement of the *Weight* of boys in the School of Christ's Hospital, showing the average, maximum, and minimum at each month, quarter, and year of age, between 9 and 16 :—

Age in Years and Months	No. of Observations	Weight in lbs. and Decimals						
		Monthly			Quarterly		Yearly	
		Average	Maximum	Minimum	No. of observations	Average	No. of observations	Average
9 0	1	48	—	—	—	—	—	—
1	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—
4	1	59	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—
6	3	58	64	52				
7	3	63	65	61	9	60·7		
8	3	61	62	59			22	58·7
9	2	57·5	58	57				
10	1	61	—	—	13	58·7		
11	10	58·7	67	56				
	Average of Monthly Averages		63·2	57				
10 0	10	63	75	52				
1	8	60	66	52	27	61		
2	9	60	70	54				
3	17	62·9	73	56				
4	14	64	81	50	44	63·4		
5	13	64·8	76	57			210	64·1
6	21	62·8	72	54				
7	13	64	75	52	64	64·2		
8	30	65·3	78	54				
9	24	64·5	80	53				
10	27	66·3	79	56	75	65·6		
11	24	63·9	77	53				
	Average of Monthly Averages		75·1	53·6				
11 0	24	64·4	77	56				
1	24	65·8	77	55	83	64·8		
2	35	64·9	76	51				
3	36	65·8	98	51				
4	29	68·5	93	56	102	66·9		
5	37	66·6	83	52				
6	33	66·1	79	52			392	67·4
7	38	67·5	81	57	102	67·7		
8	31	69·7	88	54				
9	24	67·8	81	58				
10	37	70·6	84	54	105	69·7		
11	44	70	90	46				
	Average of Monthly Averages		83·9	53·5				

NOTE.—Weight is taken without coats, waistcoats, and shoes. The average weight of clothes worn when weighed is ascertained to be 2½ lbs.

TABLE II.—STATEMENT OF THE WEIGHT, &c.—*continued.*

Age in Years and Months	No. of Observations	Weight in lbs. and Decimals						
		Monthly			Quarterly		Yearly	
		Average	Maximum	Minimum	No. of observations	Average	No. of observations	Average
12 0	33	68·4	83	56				
1	37	69·7	81	58	105	69·5		
2	35	70·2	86	58				
3	31	70·1	92	58				
4	51	70	114	51	115	70·8		
5	33	70·2	90	48				
6	47	70	86	61			410	71·3
7	38	71·3	91	48	118	71·5		
8	33	73	93	61				
9	22	74	84	64				
10	19	73·5	90	56	72	74·7		
11	31	75·9	92	62				
	Average of Monthly Averages		90·1	56·7				
13 0	21	75·5	90	60				
1	39	77·1	100	57	91	76·2		
2	31	75·7	113	55				
3	29	78·3	102	58				
4	34	77·6	131	57	98	77·3		
5	35	76·2	106	56				
6	34	76·8	93	62			353	78·3
7	35	79·5	100	56	95	79·3		
8	26	82	114	65				
9	20	78·6	91	62				
10	17	82·5	100	66	69	81·2		
11	32	82	120	66				
	Average of Monthly Averages		105	60				
14 0	26	80	104	61				
1	28	86·6	108	62	83	84·9		
2	29	87·4	133	60				
3	22	88·1	117	64				
4	27	83·2	110	64	80	86·7		
5	31	86·8	125	66				
6	22	85·2	112	69			291	86·7
7	25	86	105	57	68	88·3		
8	21	94·1	131	70				
9	18	89	112	67				
10	13	90·3	112	70	60	88·7		
11	29	87·7	129	69				
	Average of Monthly Averages		116·5	64·9				

NOTE.—Weight is taken without coats, waistcoats, and shoes. The average weight of clothes worn when weighed is ascertained to be $2\frac{1}{2}$ lbs.

TABLE II.—STATEMENT OF THE WEIGHT, &c.—*continued.*

Age in Years and Months	No. of Observations	Weight in lbs. and Decimals						
		Monthly			Quarterly		Yearly	
		Average	Maximum	Minimum	No. of observations	Average	No. of observations	Average
15 0	29	91·9	126	66				
1	33	93	113	70	91	93·9		
2	29	96·1	145	70				
3	17	100·7	140	71				
4	25	96·8	130	71	54	98·1		
5	12	96·9	122	77			236	98
6	14	102·7	122	80				
7	13	95·2	120	70	42	99		
8	15	98·6	116	81				
9	22	102·5	124	83				
10	16	104·0	129	72	49	104·8		
11	11	110	137	85				
	Average of Monthly Averages		127	74·6				
16 0	8	101·1	122	71				
1	4	96·7	116	86				
2	—	—	—	—				
3	2	113	120	106	17	103·6		
4	1	113	—	—				
5	2	113	139	88			22	104
6	—	—	—	—				
7	—	—	—	—				
8	2	98	98	98				
9	1	108	—	—	5	105·2		
10	1	107	—	—				
11	1	105	—	—				
	Average of Monthly Averages		119	90				

NOTE.—Weight is taken without coats, waistcoats, and shoes. The average weight of clothes worn when weighed is ascertained to be 2½ lbs.

TABLE III.—Statement of the empty chest-girth of boys in the School of Christ's Hospital, showing the average, maximum, and minimum at each month, quarter, and year of age, between 9 and 16 :—

Age in years and months	No. of observations	Chest-girth in Inches and Decimals						
		Monthly			Quarterly		Yearly	
		Average	Maximum	Minimum	No. of observations	Average	No. of observations	Average
9 0	1	25	—	—	—	—	—	—
1	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—
4	1	29·3	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—
6	3	25·6	26	24·2				
7	4	26·5	27·2	25·4	10	26		
8	3	26	26·6	24·6			23	25·5
9	2	26·2	26·4	26				
10	1	24	—	—	13	25·3		
11	10	25	27·1	24				
	Average of Monthly Averages		27	24·9				
10 0	10	25·6	27	23·4				
1	8	24·9	26·6	24	28	25·2		
2	10	25	25·6	24·4				
3	15	25·5	28	22·5				
4	13	25·8	28	24	39	25		
5	11	26·1	28·1	24				
6	20	25·5	28·2	22·4			194	25·8
7	11	26·1	28	24	58	25·8		
8	27	26	28	23·4				
9	23	25·7	28·4	24				
10	24	26·5	29·6	25	69	26·2		
11	22	26·3	28·6	22				
	Average of Monthly Averages		27·9	23·6				
11 0	20	25·7	28·2	23·4				
1	18	25·7	28	23	68	25·7		
2	30	25·7	28	23·4				
3	27	26	29·4	23				
4	24	26·3	28·2	24	74	26·3		
5	23	26·5	28·6	24				
6	24	25·9	28·4	23·4			279	26
7	28	26·1	29·2	23·2	72	26		
8	20	26	28·4	23				
9	12	26·4	28·3	24				
10	26	26·6	29	23	65	26·3		
11	27	25·9	30	22·7				
	Average of Monthly Averages		28·7	23·4				

NOTE.—The chest is measured over nipple and under bladebones, over the shirt. The allowance for shirt would be one inch.

TABLE III.—STATEMENT OF THE EMPTY CHEST-GIRTH, &c.—*continued.*

Age in years and months	No. of observations	Chest-girth in Inches and Decimals.						
		Monthly			Quarterly		Yearly	
		Average	Maximum	Minimum	No. of observations	Average	No. of observations	Average
12 0	21	26·6	29	24·4				
1	19	26·2	28·6	21	55	26·4		
2	15	26·5	30	22·4				
3	15	26·6	29·6	24				
4	30	26·1	28·2	22·4	60	26·5		
5	15	27	29·4	25·4			159	26·5
6	23	26·4	29·4	24				
7	11	26·1	29·4	23	42	26·4		
8	8	26·6	27·4	25				
9	1	29	—	—				
10	1	25	—	—	2	27		
11	—	—	—	—	—			
	Average of Monthly Averages		28·1	23·2				
13 0	1	25·6	—	—	—	—		
1	—	—	—	—	—	—		
2	—	—	—	—	—	—		
3	—	—	—	—	—	—		
4	—	—	—	—	—	—		
5	—	—	—	—	—	—		
6	—	—	—	—	—	—		
7	—	—	—	—	—	—		
8	—	—	—	—	—	—		
9	—	—	—	—	—	—		
10	—	—	—	—	—	—		
11	—	—	—	—	—	—		
	Average of Monthly Averages		—	—				
14 0	—	—	—	—				
1	1	29·4	—	—	3	31·1		
2	2	32	32	31·9				
3	—	—	—	—				
4	—	—	—	—	1	30·4		
5	1	30·4	—	—			20	30
6	—	—	—	—				
7	4	28·1	31	26	4	28·1		
8	—	—	—	—				
9	1	35·5	—	—				
10	4	31·2	36	27·4	12	30·3		
11	7	29·1	31·1	26·9				
	Average of Monthly Averages		32·5	28·1				

NOTE.—The chest is measured over nipple and under bladebones, over the shirt. The allowance for shirt would be one inch.

TABLE III.—STATEMENT OF THE EMPTY CHEST-GIRTH, &c.—*continued.*

Age in years and months	No. of observations	Chest-girth in Inches and Decimals						
		Monthly			Quarterly		Yearly	
		Average	Maximum	Minimum	No. of observations	Average	No. of observations	Average
15 0	13	30·1	34·4	26·4				
1	22	29·5	33	25·2	55	29·7		
2	20	29·7	34·4	27				
3	11	30·2	35	26				
4	17	30·8	32	26	34	30·3		
5	6	31·3	34	28·4			153	30·3
6	8	31·4	34	28				
7	6	28·9	34	26	26	30·3		
8	12	30·3	33·4	28				
9	14	30·1	34	27·4				
10	14	31·0	34·4	28	38	31·1		
11	10	32·2	35	29				
	Average of Monthly Averages		34	27·1				
16 0	6	31·2	33	28·4	—	—		
1	5	29·8	31	26·4	—	—		
2	—	—	—	—				
3	1	32·4	—	—				
4	—	—	—	—				
5	1	29	—	—			17	30·8
6	—	—	—	—				
7	—	—	—	—				
8	2	30·7	32	29·4	—	—		
9	1	31·4	—	—				
10	—	—	—	—				
11	1	33	—	—				
	Average of Monthly Averages		32	28·1				

NOTE.—The chest is measured over nipple and under bladebones, over the shirt. The allowance for shirt would be one inch.

TABLE IV.—Abstract of the height, weight, and chest-girth of the boys, observed at each year of age, with the actual and proportionate rate of increase:—

Age	Number of Observations	Average	Maximum	Minimum	Average of Monthly Maxima	Average of Monthly Minima	Annual Increase	Percentage Proportion of Increase at each Age
	Height in Inches and Decimals							
							Inches	
From 9 to 10.	22	50·8	57	48·4	53	49·4	—	—
„ 10 „ 11.	210	52·2	57	47·4	55·3	49·1	1·4	2·75
„ 11 „ 12.	392	53·7	60·4	47·4	58·4	49·1	1·5	2·87
„ 12 „ 13.	410	54·7	61	48·4	59·1	50·3	1	1·86
„ 13 „ 14.	353	56·7	65·7	48	62·1	51·3	2	3·65
„ 14 „ 15.	291	58·6	66·4	50·1	64·2	53·2	1·9	3·35
„ 15 „ 16.	236	61·3	69·4	55·6	66·7	55·6	2·7	4·60
„ 16 „ 17.	22	62·8	68·2	56·6	65·7	60·1	1·5	2·44
Total . . .	1936							
	Weight in lbs. and Decimals							
							lbs.	
From 9 to 10.	22	58·7	67	52	63·2	57	—	—
„ 10 „ 11.	210	64·1	81	50	75·1	53·6	5·4	9·20
„ 11 „ 12.	392	67·4	98	46	83·9	53·5	3·3	5·14
„ 12 „ 13.	410	71·3	114	48	90·1	56·7	3·9	5·78
„ 13 „ 14.	353	78·3	131	55	105	60	7	9·95
„ 14 „ 15.	291	86·7	133	57	116·5	64·9	8·4	10·72
„ 15 „ 16.	236	98	145	66	127	74·6	11·3	13·03
„ 16 „ 17.	22	104	139	71	119	90	6	6·12
Total . . .	1936							
	Chest-girth in Inches and Decimals							
							Inches	
From 9 to 10.	23	25·5	27·2	24	27	24·9	—	—
„ 10 „ 11.	194	25·8	29·6	22	27·9	23·6	0·3	1·17
„ 11 „ 12.	279	26	30	22·7	28·7	23·4	0·2	0·79
„ 12 „ 13.	159	26·5	30	21	28·1	23·2	0·5	1·92
„ 13 „ 14.	1	25·6	—	—	—	—	—	—
„ 14 „ 15.	20	30	36	26	32·5	28·1	3·5	13·20
„ 15 „ 16.	153	30·3	35	25·2	34	27·1	0·3	1·00
„ 16 „ 17.	17	30·8	33	26·4	32	28·1	0·5	1·62
Total . . .	846							

TABLE V.—Abstract of the average height, weight, and chest-girth of boys in the School of Christ's Hospital, at each year of age, and the increase and percentage proportion of increase at each age :—

Age	Number of Observations		Average at each Age			Increase at each Age			Percentage Proportion of Increase at each Age		
	Height and Weight	Chest-girth	Height	Weight	Chest-girth	Height	Weight	Chest-girth	Height	Weight	Chest-girth
			In.	lbs.	In.	In.	lbs.	In.	In.	lbs.	In.
From 9 to 10	22	23	50·8	58·7	25·5	—	—	—	—	—	—
„ 10 „ 11	210	194	52·2	64·1	25·8	1·4	5·4	0·3	2·75	9·20	1·17
„ 11 „ 12	392	279	53·7	67·4	26	1·5	3·3	0·2	2·87	5·14	0·79
„ 12 „ 13	410	159	54·7	71·3	26·5	1	3·9	0·5	1·86	5·78	1·92
„ 13 „ 14	353	1	56·7	78·3	25·6	2	7	—	2·65	9·95	—
„ 14 „ 15	291	20	58·6	86·7	30	1·9	8·4	3·5	3·35	10·72	13·20
„ 15 „ 16	236	153	61·3	98	30·3	2·7	11·3	0·3	4·60	13·03	1·00
„ 16 „ 17	22	17	62·8	104	30·8	1·5	6	0·5	2·44	6·12	1·62
Total . . .	1936	846									

TABLE VI.—Statement of the weight and chest-girth in relation to height of boys in the School of Christ's Hospital, between the ages of 9 and 16 :—

Height	Weight		Chest-girth	
	Number of Observations	Average in lbs.	Number of Observations	Average in inches
ft. in.				
5 9	1	135	1	33·4
5 8	2	116	1	31
5 7	8	124	5	33
5 6	15	122	10	32·6
5 5	22	118	10	32·1
5 4	34	108	14	31·8
5 3	46	103	20	30·3
5 2	53	100	23	31·2
5 1	73	96	26	30·5
5 0	100	91	27	29·7
4 11	109	86	17	28·7
4 10	135	84	29	28·7
4 9	148	79	28	27·8
4 8	189	75	56	27
4 7	201	73	73	26·9
4 6	211	70	96	26·3
4 5	181	67	105	26
4 4	166	64	94	26
4 3	106	61	66	25·5
4 2	87	59	75	25·5
4 1	50	58	40	25·5
4 0	12	54	11	24·6
3 11	5	52	5	24·8

TABLE VII.—Statement of the percentage proportion which the averages of maxima and minima bear to the general averages of height, weight, and chest-girth among boys in the School of Christ's Hospital, between the ages of 9 and 16 :—

Years of Age	Height		Weight		Chest-girth	
	Maxima	Minima	Maxima	Minima	Maxima	Minima
	+	−	+	−	+	−
9	3·9	2·7	7·6	2·9	6	2·3
10	5·9	5·9	17·1	16·3	8·1	8·1
11	8·7	8·5	24·4	20·6	10·4	10
12	8	8	26·3	20·4	6	12·4
13	9·5	9·5	34·1	23·3	—	—
14	9·5	9·2	34·3	25·1	8	7
15	8·8	9·3	29·8	23·8	12·2	10·5
16	4·6	4·3	14·4	13·4	3·9	8·8

TABLE VIII.—Abstract of the mean height, weight, and chest girth of boys in the School of Christ's Hospital, between the ages of 9 and 16 :—

Age		Quarterly			Yearly		
		Height	Weight	Chest-girth	Height	Weight	Chest-girth
Years	Months	Inches	Lbs.	Inches	Inches	Lbs.	Inches
—		—	—	—	62·1	101	31
16	0	—	—	—	—		
15	9	63·1	102·5	31			
15	6	62·2	98	30·4			
15	3	61	95	30·4	61·7	95·5	30·4
15	0	60·7	92·5	29·4			
14	9	59·2	86	29·2			
14	6	59·4	87	—			
14	3	58·5	85·5	—	59·1	85·5	29·4
14	0	58	83·5	—			
13	9	57·2	80	—			
13	6	56·5	77	—			
13	3	56·2	75·5	—	56	78	
13	0	56·2	75	—			
12	9	56·2	74·5	—			
12	6	54·5	72	26·4			
12	3	54	69·5	26·4	54·5	70·5	26·4
12	0	53·7	68·5	27			
11	9	—	69	26			
11	6	—	66·5	26			
11	3	—	65	26	53·2	65·5	26
11	0	—	63	25·6			
10	9	—	64	26·2			
10	6	—	65	25·6			
10	3	—	62·5	25·6	51·8	63	26
10	0	—	59·5	25			
9	0	—	—	—	49·8	58·5	25·4

TABLE IX.—Statement of the mean height of boys in the School of Christ's Hospital, between the ages of 9 and 16 :—

Height in Inches and Half-Inches	Number of Boys at each Age								
	9	10	11	12	13	14	15	16	Total 9 to 16
68	—	—	—	—	—	—	1	1	
67·5	—	—	—	—	—	—	1	—	
67	—	—	—	—	—	—	5	2	
66·5	—	—	—	—	—	—	1	—	
66	—	—	—	—	—	1	13	1	
65·5	—	—	—	—	1	1	6	—	
65	—	—	—	—	—	4	8	3	
64·5	—	—	—	—	—	—	3	—	
64	—	—	—	—	3	9	16	—	
63·5	—	—	—	—	—	—	4	1	
63	—	—	—	1	2	9	27	2	
62·5	—	—	—	—	—	3	8	—	
62	—	—	—	—	4	13	22	3	
61·5	—	—	—	—	4	8	6	1	
61	—	—	—	3	7	22	21	1	
60·5	—	—	—	1	3	10	2	1	
60·0	—	—	3	4	20	28	24	3	
59·5	—	—	—	1	6	8	3	1	
59	—	—	5	6	27	33	16	—	
58·5	—	—	2	5	11	8	3	1	
58	—	—	6	21	29	28	15	—	
57·5	—	—	3	11	9	4	1	—	
57	1	1	10	31	43	20	9	—	
56·5	—	3	3	9	10	8	1	—	
56	—	8	24	56	35	25	4	—	
55·5	—	3	14	16	12	1	2	—	
55	—	12	43	41	38	17	5	—	
54·5	—	7	15	12	16	6	1	1	
54	—	18	53	46	24	9	3	—	
53·5	—	6	17	17	4	3	—	—	
53	—	24	41	43	15	7	4	—	
52·5	1	13	16	19	3	1	—	—	
52	3	23	45	30	12	1	—	—	
51·5	—	7	12	6	3	1	—	—	
51	4	22	28	16	6	1	—	—	
50·5	1	8	11	4	1	—	—	—	
50	6	30	16	4	1	1	—	—	
49·5	2	6	8	3	—	—	—	—	
49	4	9	12	3	4	1	—	—	
48·5	—	6	—	—	—	—	—	—	
48	1	4	1	1	—	—	—	—	
47·5	—	—	3	—	—	—	—	—	
47	1	—	1	—	—	—	—	—	
Total	24	210	932	410	353	291	236	22	1938

The middle bar in each column indicates the actual mean: the upper bar the mean of excess, and the lower bar the mean of defect.

TABLE X.—Statement of the mean weight of boys in the School of Christ's Hospital, between the ages of 9 and 16 :—

Weight in lbs.	Number of Boys at each Age							
	9	10	11	12	13	14	15	16
145	—	—	—	—	—	—	1	—
140	—	—	—	—	—	—	1	—
139	—	—	—	—	—	—	—	1
137	—	—	—	—	—	—	1	—
136	—	—	—	—	—	—	1	—
135	—	—	—	—	—	—	1	—
133	—	—	—	—	—	—	—	—
132	—	—	—	—	—	2	1	—
131	—	—	—	—	—	1	3	—
130	—	—	—	—	—	—	1	—
129	—	—	—	—	—	—	1	—
128	—	—	—	—	—	—	—	—
125	—	—	—	—	—	2	1	—
124	—	—	—	—	—	—	—	—
122	—	—	—	—	—	—	5	1
121	—	—	—	—	1	—	3	—
120	—	—	—	—	1	—	4	1
119	—	—	—	—	—	—	2	—
8	—	—	—	—	—	1	5	—
7	—	—	—	—	—	2	4	—
6	—	—	—	—	—	1	4	1
5	—	—	—	—	—	—	4	2
4	—	—	—	—	1	—	3	—
3	—	—	—	—	1	—	3	1
2	—	—	—	—	—	3	7	—
1	—	—	—	—	—	—	3	1
110	—	—	—	—	—	2		—
109	—	—	—	—	—	—	2	—
8	—	—	—	—	—	2	4	1
7	—	—	—	—	—	—	3	1
6	—	—	—	—	1	4	3	1
5	—	—	—	—	2	2	9	—
4	—	—	—	—	—	4	5	—
3	—	—	—	—	—	4	2	—
2	—	—	—	—	1	7	4	—
1	—	—	—	—	—	7	3	
100	—	—	—	—	3	7	4	2
99	—	—	—	—	1	5	2	—
8	—	—	1	—	5	6	11	2
7	—	—	—	—	3	7	3	1
6	—	—	—	—	3	7	8	1
5	—	—	—	—	2	7	7	
4	—	—	—	—	4	5	10	1
3	—	—	1	1	3	6	5	—
2	—	—	—	4	1	5	5	—
1	—	—	—	1	6	5	7	—
90	—	—	2	3	15	8	10	—
89	—	—	—	2	4	8	4	—
8	—	—	1	5	8	11	8	1

The middle bar in each column indicates the actual mean; the upper bar the mean of excess, and the lower bar the mean of defect.

TABLE X.—STATEMENT OF THE MEAN WEIGHT, &c.—*continued.*

Weight in lbs.	Number of Boys at each Age							
	9	10	11	12	13	14	15	16
7	—	—	—	2	7	7	3	—
6	—	—	1	7	11	11	7	1
5	—	—	—	3	4	5	6	—
4	—	—	6	8	13	10	2	—
3	—	—	2	5	6	5	2	1
2	—	—	3	5	16	9	2	—
1	—	2	7	16	10	11	7	—
80	—	1	8	11	12	13	2	—
79	—	1	5	12	10	5	1	—
8	—	3	4	10	13	8	2	—
7	—	5	10	6	13	11	4	—
6	—	2	11	22	16	12	3	—
5	—	4	8	17	21	8	1	—
4	—	6	20	20	14	5	2	—
3	—	6	10	22	14	14	—	—
2	—	6	19	16	15	7	6	—
1	—	4	10	18	11	2	1	1
70	—	12	19	22	15	10	4	—
69	—	10	12	14	9	5	2	—
8	—	4	18	21	8	1	—	—
7	1	6	12	11	10	1	—	—
6	—	21	32	15	10	3	1	—
5	1	7	17	21	8	—	—	—
4	1	4	16	20	2	2	—	—
3	2	8	25	11	4	1	—	—
2	2	13	19	17	5	2	—	—
1	3	9	17	18	2	1	—	—
60	—	8	21	9	1	2	—	—
59	3	13	15	—	1	—	—	—
8	3	12	6	6	1	—	—	—
7	1	7	6	1	2	1	—	—
6	5	23	14	5	2	—	—	—
5	—	2	1	—	1	—	—	—
4	—	4	2	—	—	—	—	—
3	—	2	—	—	—	—	—	—
2	1	4	4	—	—	—	—	—
1	—	—	4	1	—	—	—	—
50	—	1	1	—	—	—	—	—
49	—	—	—	—	—	—	—	—
8	1	—	—	2	—	—	—	—
7	—	—	—	—	—	—	—	—
6	—	—	2	—	—	—	—	—
Total . . .	24	210	392	410	353	291	236	22

The middle bar in each column indicates the actual mean; the upper bar the mean of excess, and the lower bar the mean of defect.

TABLE XI.—Statement of the mean chest-girth of boys in the School of Christ's Hospital, between the ages of 9 and 16:—

Chest-girth in Inches and Eighths	Number of Boys at each Age							
	9	10	11	12	13	14	15	16
35 4	—	—	—	—	—	1	—	—
35	—	—	—	—	—	—	2	—
34 6	—	—	—	—	—	—	—	—
4	—	—	—	—	—	—	3	—
2	—	—	—	—	—	—	—	—
34	—	—	—	—	—	—	6	—
33 6	—	—	—	—	—	—	—	—
4	—	—	—	—	—	—	4	—
2	—	—	—	—	—	—	—	—
33	—	—	—	—	—	1	8	2
32 6	—	—	—	—	—	—	—	—
4	—	—	—	—	—	—	3	1
2	—	—	—	—	—	—	—	—
32	—	—	—	—	—	2	16	3
31 6	—	—	—	—	—	1	—	—
4	—	—	—	—	—	—	6	1
2	—	—	—	—	—	—	—	—
31	—	—	—	—	—	2	16	3
30 6	—	—	—	—	—	—	—	1
4	—	—	—	—	—	1	13	1
2	—	—	—	—	—	—	1	—
30	—	—	1	1	—	—	19	—
29 6	—	1	—	3	—	—	1	—
4	—	—	2	1	—	3	7	2
2	1	—	3	—	—	1	—	—
29	—	—	1	5	—	—	12	1
28 6	—	2	5	7	—	—	—	—
4	—	2	7	3	—	—	3	1
2	—	2	8	3	—	—	2	—
28	—	11	12	5	—	1	15	—
27 6	—	5	4	3	—	—	—	—
4	—	6	9	11	—	2	3	—
2	2	4	3	10	—	—	2	—
27	1	13	26	18	—	2	3	—
26 6	2	11	10	9	—	1	1	—
4	2	19	18	10	—	—	3	1
2	1	6	15	3	—	—	3	—
26	2	15	30	19	—	2	—	—
25 6	1	13	23	1	1	—	—	—
4	2	11	21	13	—	—	—	—
2	1	4	13	2	—	—	1	—
25	2	24	21	12	—	—	—	—
24 6	1	4	6	3	—	—	—	—
4	2	14	13	7	—	—	—	—
2	1	5	4	1	—	—	—	—
24	4	14	9	5	—	—	—	—
23 6	—	1	1	—	—	—	—	—
4	—	4	3	—	—	—	—	—
2	—	—	1	—	—	—	—	—
23	—	—	6	1	—	—	—	—
22 6	—	1	2	—	—	—	—	—
4	—	1	1	2	—	—	—	—
2	—	—	—	—	—	—	—	—
22	—	1	1	—	—	—	—	—
21	—	—	—	1	—	—	—	—
Total . . .	25	194	279	159	1	20	153	17

The middle bar in each column indicates the actual mean; the upper bar the mean of excess, and the lower bar the mean of defect.

TABLE I.—SHOWING THE STATURE (WITHOUT SHOES)

Age last Birth-day	British-born (Roberts's 'Manual of Anthropometry,' pp. 72 and 80)									American-born (Bowditch 'On the Growth of Children,' p. 41. Baxter, 'Statist. Med. and Anthrop.' vol. i. p. 19)		
	Professional Class Town and Country			Labouring and Artisan Classes in Towns only			Average English					
	Males			Males			Males			Males		
	No.	Inches	Mètres	No.	Inches	Mètres	No.	Inches	Mètres	No.	Inches	Mètres
Birth	—	—	—	100	19·34	0·491	100	—	0·491	—	—	—
1	—	—	—	—	—	—	—	—	—	8	29·13	0·740
2	—	—	—	—	—	—	—	—	—	8	32·85	0·834
3	—	—	—	—	—	—	—	—	—	8	36·37	0·921
4	—	—	—	21	38·45	0·977	21	38·45	0·977	9	39·50	1·003
5	—	—	—	175	41·16	1·046	175	41·16	1·046	848	41·57	1·056
6	—	—	—	327	43·18	1·097	327	43·18	1·096	1258	43·75	1·111
7	3	46·16	1·173	781	45·01	1·144	784	45·58	1·158	1419	45·74	1·162
8	16	47·31	1·202	1036	46·99	1·194	1052	47·15	1·198	1481	47·76	1·213
9	59	50·18	1·275	1182	49·22	1·251	1241	49·70	1·263	1437	49·69	1·262
10	74	53·40	1·357	1119	50·52	1·284	1193	51·79	1·320	1363	51·68	1·313
11	150	54·91	1·396	1080	51·52	1·309	1230	53·21	1·352	1293	53·33	1·354
12	248	56·97	1·448	620	52·99	1·347	868	54·98	1·397	1253	55·11	1·400
13	473	58·79	1·495	991	55·93	1·422	1464	57·36	1·458	1160	57·21	1·453
14	477	61·11	1·553	2247	57·76	1·468	2424	59·43	1·511	908	59·88	1·521
15	541	63·47	1·613	754	60·58	1·539	1297	62·02	1·575	636	62·30	1·582
16	686	66·40	1·687	1018	62·93	1·599	1704	64·66	1·643	827	64·55	1·651
17	1602	67·86	1·724	453	64·45	1·638	2055	66·15	1·681	1129	65·90	1·673
18	1522	68·29	1·735	153	65·47	1·663	1675	66·88	1·699	30,540	66·52	1·689
19	794	68·72	1·747	97	66·02	1·678	891	67·37	1·711	14,994	67·07	1·703
20	391	69·13	1·757	69	66·31	1·685	460	67·72	1·721	11,526	67·51	1·714
21	340	69·16	1·758	55	66·84	1·699	395	68·00	1·728	14,146	67·78	1·721
22	205	68·93	1·752	36	66·25	1·684	241	67·59	1·718	10,479	67·92	1·725
23	91	68·52	1·741	29	66·23	1·683	120	67·37	1·712	8907	68·01	1·725
24	45	68·95	1·752	34	66·62	1·693	79	67·78	1·723	7335	68·02	1·727
25										7940	68·05	1·728
26										6986	68·09	1·729
27										6351	68·11	1·730
28	70	69·06	1·755	72	66·95	1·702	142	68·00	1·728	6033	68·13	1·730
29										4447	68·17	1·731
30										6256	68·18	1·731
31	—	—	—	—	—	—	—	—	—	5562	68·20	1·732
32	—	—	—	—	—	—	—	—	—	4635	68·20	1·732
33	—	—	—	—	—	—	—	—	—	3939	68·29	1·734
34	—	—	—	—	—	—	—	—	—	2782	68·35	1·736
35	—	—	—	—	—	—	—	—	—	4966	68·47	1·739
36	—	—	—	—	—	—	—	—	—	4138	68·28	1·734
37	—	—	—	—	—	—	—	—	—	4172	68·26	1·734
38	—	—	—	—	—	—	—	—	—	4014	68·24	1·733
39	—	—	—	—	—	—	—	—	—	3402	68·23	1·733
40	—	—	—	—	—	—	—	—	—	15,750	68·23	1·733
50	—	—	—	—	—	—	—	—	—	—	—	—
60	—	—	—	—	—	—	—	—	—	—	—	—
70	—	—	—	—	—	—	—	—	—	—	—	—
80	—	—	—	—	—	—	—	—	—	—	—	—
90	—	—	—	—	—	—	—	—	—	—	—	—

OF THE BRITISH RACE IN ENGLAND AND AMERICA.

Anglo-American (Roberts, Bowditch, and Baxter) All Classes			American-born (Bowditch 'On the Growth of Children,' p. 51)			Belgian (Quetelet, 'Anthropométrie,' p. 177)						Age last Birth-day
Males			Females			Males.			Females			
No.	Inches	Mètres	No.	Inches	Mètres	No.	Inches	Mètres	No.	Inches	Mètres	
100	19·34	0·491	100	18·98	0·482	The number of observations is not given, but they were probably ten for each age. See 'Anthropométrie,' p. 24.	19·68	0·500	—	19·45	0·494	Birth
8	29·13	0·740	7	27·86	0·708		27·48	0·698	—	27·16	0·690	1
8	32·85	0·834	8	31·60	0·796		31·14	0·791	—	30·75	0·781	2
8	36·37	0·921	8	35·65	0·906		34·01	0·864	—	33·63	0·852	3
30	38·97	0·989	10	38·36	0·974		36·49	0·927	—	36·02	0·915	4
1023	41·36	1·051	605	41·29	1·049		38·85	0·987	—	38·35	0·974	5
1585	43·46	1·104	987	43·35	1·101		41·18	1·046	—	40·58	1·031	6
2203	45·66	1·161	1199	45·52	1·156		43·46	1·104	—	42·81	1·087	7
2533	47·45	1·206	1299	47·58	1·209		45·74	1·162	—	44·97	1·142	8
2678	49·46	1·263	1149	49·37	1·254		47·95	1·218	—	47·10	1·196	9
2556	51·73	1·317	1089	51·34	1·304		50·11	1·273	—	49·17	1·249	10
2523	53·27	1·354	936	53·42	1·357		52·16	1·325	—	51·21	1·301	11
2121	55·04	1·398	935	55·88	1·419		54·13	1·375	—	53·23	1·352	12
2624	57·28	1·455	830	58·16	1·477		56·02	1·423	—	55·11	1·400	13
3632	59·65	1·516	675	59·94	1·523		57·83	1·469	—	56·94	1·446	14
1931	62·16	1·579	459	61·10	1·552		59·56	1·513	—	58·60	1·488	15
2063	64·61	1·647	353	61·59	1·564		61·18	1·554	—	59·90	1·521	16
3184	66·02	1·677	233	61·92	1·572		62·75	1·594	—	60·87	1·546	17
32,215	66·70	1·695	155	61·95	1·573		64·17	1·630	—	61·53	1·563	18
15,885	67·22	1·708	—	—	—		65·15	1·655	—	61·82	1·570	19
11,986	67·61	1·718	—	—	—		65·75	1·670	—	61·98	1·574	20
14,541	67·89	1·728	—	—	—		—	—	—	—	—	21
10,720	67·75	1·722	—	—	—		—	—	—	—	—	22
9027	67·69	1·720	—	—	—		—	—	—	—	—	23
7414	67·90	1·725	—	—	—		—	—	—	—	—	24
							66·22	1·682	—	62·13	1·578	25
												26
												27
38,155	68·12	1·728	—	—	—		—	—	—	—	—	28
												29
							66·38	1·686	—	62·21	1·580	30
												31
												32
												33
												34
37,610	68·28	1·735	—	—	—		—	—	—	—	—	35
												36
												37
												38
												39
							66·38	1·686	—	62·21	1·580	40
—	—	—	—	—	—		66·38	1·686	—	62·21	1·580	50
—	—	—	—	—	—		65·98	1·676	—	61·78	1·571	60
—	—	—	—	—	—		65·35	1·660	—	61·27	1·556	70
—	—	—	—	—	—		64·41	1·636	—	60·40	1·534	80
—	—	—	—	—	—		63·38	1·610	—	59·54	1·510	90

TABLE II.—SHOWING THE WEIGHT (INCLUDING CLOTHES)

Age last Birthday	British-born (Roberts's 'Manual of Anthropometry,' pp. 74 and 82)									American-born (Bowditch, 'On the Growth of Children,' p. 43. Baxter, 'Statistics, Medical and Anthropological,' p. 53)		
	Professional Class Town and Country			Labouring and Artisan Classes in Towns only			Average English					
	Males			Males			Males					
	No.	Lbs.	Kilos.	No.	Lbs.	Kilos.	No.	Lbs.	Kilos.	No.	Lbs.	Kilos.
Birth	—	—	—	100	7·55	3·4	100	7·55	3·4	—	—	—
1	—	—	—	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—	—	—	—	—
4	—	—	—	21	41·16	18·6	21	41·16	18·6	—	—	—
5	—	—	—	176	49·99	22·7	176	49·99	22·7	848	41·09	18·6
6	—	—	—	327	54·19	24·6	327	54·19	24·6	1258	45·17	20·5
7	—	—	—	631	56·89	25·9	631	59·89	25·9	1419	49·07	22·3
8	16	60·00	27·3	1038	59·00	26·8	1038	59·50	27·0	1481	53·92	24·5
9	59	62·02	28·1	1203	62·56	28·4	1262	62·29	28·3	1437	59·23	26·9
10	74	67·44	30·6	1126	66·31	30·1	1200	66·87	30·4	1363	65·30	29·6
11	150	72·94	33·1	979	69·46	31·5	1129	71·20	32·3	1293	70·18	31·8
12	248	80·33	36·5	615	73·68	33·4	863	77·00	35·0	1253	76·92	34·9
13	473	88·60	40·2	1054	78·27	35·6	1527	83·43	37·9	1160	84·84	38·5
14	477	99·21	45·1	2094	84·61	38·4	2571	91·91	41·7	908	94·91	43·1
15	541	110·42	50·2	910	96·79	44·0	1451	103·60	47·1	636	107·10	48·6
16	686	128·34	58·3	1038	108·70	49·4	1724	118·52	53·8	359	121·01	55·0
17	1602	141·03	64·1	504	121·53	55·2	2106	131·28	59·6	192	127·49	57·8
18	1522	146·00	66·3	147	128·14	58·2	1669	137·57	62·5	84	132·55	60·1
19	794	148·20	67·4	105	133·39	60·6	899	141·79	64·4	—	—	—
20	391	152·07	69·1	68	142·61	64·8	459	146·34	66·5	29	146·41	66·5
21	340	152·34	69·2	54	142·83	64·9	394	147·58	67·1	38	151·50	68·9
22	205	154·78	70·3	39	141·13	64·1	244	147·95	67·2	34	153·53	69·8
23	91	151·70	69·0	26	141·00	64·1	117	146·35	66·5	30	154·23	70·1
24	45	149·20	68·0	35	142·37	64·7	80	145·78	66·2	42	148·09	67·3
25												
26												
27												
28	70	155·20	70·54	60	146·05	66·4	130	150·62	68·4	247	149·20	67·8
29												
30												
40	—	—	—	—	—	—	—	—	—	578	151·71	68·9

OF THE BRITISH RACE IN ENGLAND AND AMERICA.

Anglo-American (Roberts, Bowditch, and Baxter) All Classes			American-born (Bowditch 'On the Growth of Children,' p. 47)			Belgian (Quetelet's 'Anthropométrie,' p. 346)						Age last Birth-day
Males			Females			Males			Females			
No.	Lbs.	Kilos.	No.	Lbs.	Kilos.	No.	Lbs.	Kilos.	No.	Lbs.	Kilos.	
100	7·55	3·4	100	7·23	—	Number of observations not given.	6·83	3·1	Number of observations not given.	6·61	3·0	Birth
—	—	—	—	—	—		19·84	9·0		18·96	8·6	1
—	—	—	—	—	—		24·25	11.0		24·25	11·0	2
—	—	—	—	—	—		27·55	12·5		27·33	12·4	3
21	41·16	18·6	—	—	—		30·87	14·0		30·65	13·9	4
1024	45·54	20·7	605	39·66	18·0		35·06	15·9		33·73	15·3	5
1585	49·68	22·6	987	43·28	19·6		39·24	17·8		36·82	16·7	6
2050	52·98	24·1	1199	47·46	27·1		43·43	19·7		39·25	17·8	7
2519	56·46	25·6	1299	52·04	23·4		47·62	21·6		41·89	19·0	8
2699	60·76	27·5	1149	57·07	25·9		51·81	23·5		46·30	21·0	9
2563	66·08	30·0	1089	62·35	28·3		55·56	25·2		50·93	23·1	10
2422	70·69	32·1	936	68·84	31·2		59·53	27·0		56·22	25·5	11
2116	76·96	35·0	935	78·31	35·5		63·94	29·0		63·93	29·0	12
2687	84·13	38·3	830	88·65	40·2		72·98	33·1		71·66	32·5	13
3479	93·41	42·4	675	98·43	44·6		81·80	37·1		80·04	36·3	14
2087	105·35	47·9	459	106·08	48·1		90·84	41·2		88·20	40·0	15
2083	119·76	54·4	353	112·03	50·8		100·10	45·4		95·91	43·5	16
2298	129·38	58·8	233	115·53	52·4		109·58	49·7		103·20	46·8	17
1753	134·81	61·2	155	115·16	52·2		118·84	53·9		109·80	49·8	18
899	141·79	64·4	—	—	—		127·00	57·6		114·88	52·1	19
488	146·87	66·7	—	—	—		131·19	59·5		117·30	53·2	20
432	149·54	68·0	—	—	—		134·94	61·2		119·73	54·3	21
278	150·74	68·5	—	—	—		138·69	62·9		120·82	54·8	22
147	150·29	68·3	—	—	—		142·22	64·5		121·71	55·2	23
122	146·93	66·8	—	—	—		—	—		—	—	24
							145·97	66·2		123·04	55·8	25
												26
												27
377	149·91	68·1										28
												29
							145·75	66·1		121·93	55·3	30
578	151·71	68·9	—	—	—		—	—		—	—	40

By the kindness of the authorities, a circular from the Committee was distributed with the annual official return forms to every industrial and reformatory school in the Kingdom, and returns have been obtained from several such schools; some of the results of which are shown in the foregoing tables.

The Committee have also addressed insurance companies with the view of inducing their medical officers to keep accurate records of the physical measurements of persons whose lives are proposed for insurance, and in some instances have been informed that attention will be given to the matter.

They have also addressed the following circular to the head-masters of Public Schools:—

'The Anthropometric Committee of the British Association have directed me to forward you the enclosed papers, with the view of calling your attention to the great service which the Public Schools might render to Anthropometric Science by establishing a system of statistical record of height, weight, strength, &c., for the purpose of ascertaining the laws of growth and development in youth and adolescence.

'Some schools have already furnished the Committee with valuable information of the kind desired. Marlborough School, for example, has, for the last seven years, published in the Reports of the School Natural History Society details of height, weight, chest and other measurements of the boys; and these statistics have been abstracted under the direction of the Committee. The Warden of Christ's Hospital, Major Brackenbury, has for several years recorded the same details.

'The Committee hope that you may be induced to attempt a similar record in your own school, and I am directed to say that they will gladly render any assistance they can in setting it on foot. They are confident that, when once established, you will find the materials collected so full of interest and usefulness in many ways, that you will not regret any little trouble it may give you at the outset, and they therefore do not refrain from asking at your hands this service to Science, however unwilling they may be to trespass upon time already fully occupied.

'The Medical Officer and the Drill Master of the School would, no doubt, do whatever may be necessary towards preparing a complete and accurate record.'

Several replies to this circular have already been received from public schools; among them, the Head-master of Eton (the Rev. J. J. Hornby, D.D.), who writes that he will be happy to do what he can to establish a system of statistical record of height, weight, strength, &c., at Eton, for the purpose of the Committee, at the termination of the present vacation.

Mr. Roberts, a member of the Committee, whose 'Manual of Anthropometry' is of the utmost value to inquirers, has furnished the Committee with a series of observations, illustrated by diagrams, and accompanied by the following remarks on the establishment of a standard of stature and weight. These are given as a specimen of the manner in which the information the Committee is collecting may be made available.

'The accompanying tables and charts show that the average height and weight varies with the social position and occupation of the people, and to obtain the typical proportions of the British race it would be necessary to measure a proportionate number of individuals of each class, or a community which comprised all the classes in the proportions in which

they exist in the whole nation. If we take the census of 1871 we shall find that such a model community would consist of 14·82 per cent. of the non-labouring class, 47·46 per cent. of the labouring class, and 37·72 per cent. of the artisan and operative classes. But as many trades are confined to certain districts it would be very difficult to find such a representative population in a limited space in this country. The nearest approach to one would be found in some of our larger county towns, such as York, Derby, or Exeter, with a large portion of the surrounding agricultural districts.

'As the statistics which I have collected in England represent various classes rather than the general population, I have arranged them in a double series—a most favoured class and a least favoured class—and I have adopted the average of the two extremes as typical of the English nation. The American statistics, with which I have compared my own, are very valuable, as they represent the general population of the United States. Dr. Bowditch's data were collected "in nearly all the public (common) schools of the city of Boston, in several schools in South Boston, Roxbury, Charlestown, and Jamaica Plain; in the Institute of Technology, in two Latin schools, a school for young ladies, and in several public (common) schools in Brookline," ("On the Growth of Children," 8th An. Rep. State Board of Health of Mass., 1877), and Dr. J. H. Baxter thus vouches for the representative character of the statistics published by the United States Government:—"It should be borne in mind that this statistical matter does not relate to soldiers already in the service—picked men in no wise representing the masses—but to the people, the men engaged in every occupation; the professional man and the man of letters, the trader, the merchant, the clerk, the artisan and the unskilled labourer." ("Statist. Med. and Anthrop.," vol. i. p. 19.)

'The accompanying tables and charts show the relation which exists between the height and weight (1) of the most favoured and the least favoured classes of the English population; (2) between the English and Americans of British origin; (3) between the two sexes of the British race; and (4) between the British and Belgian populations of both sexes.

'1. *The height and weight of the English male population.* (Chart tracings No. 1; tables I. and II., columns 1, 2, and 3.) From birth to the age of 6 or 7 years the statistical data are imperfect, but it is probable from the directions of the curves of growth that all classes of the English population are about the same in height and weight at this period. After the age of 8 years the curves diverge very rapidly, the divergence being due to a slower development of the labouring and artisan class.

'After 8 years the professional class exceeds the labouring and artisan class, thus:—

	Height. Inches.	Weight. lbs.
At 8 years the Professional Class exceeds the Labouring and Artisan Class by	0·32	1·0
„ 10 years „ „ „ „	2·88	1·13
„ 12 „ „ „ „ „	3·98	6·65
„ 14 „ „ „ „ „	3·35	14·60
„ 16 and 17 years „ „ „ „	3·44	19·55
„ 18 „ 19 „ „ „ „ „	2·76	16·33
„ 20 „ 21 „ „ „ „ „	2·50	9·50
„ 25 to 30 „ „ „ „ „	2·11	9·15

'The greatest difference in height is at 12 years, when it amounts to about 4 inches; the greatest difference in weight is at 17–18 years, when it amounts to nearly 20 lbs. The full stature is attained earlier in the professional than the artisan class; in the former about the age of 21 years, and in the latter between 25 and 30 years. The American statistics show that a slight increase in height takes place up to the 35th year. The growth in weight does not cease with that of the stature, but continues slowly to increase in both classes up to about the 30th year.

'2. *The relation between the height and weight of English-born and American-born subjects.* (Chart tracings No. 2; tables I. and II., columns 3, 4, and 5.)

'A comparison of the average stature of the English and American branches of the British race shows that they are nearly identical from the age of 4 years to the period of full growth, but the weights differ at the two ends of the curves.

'In stature, between the ages of 4 and 8 years, the American exceed the English by rather less than half an inch; but this is, no doubt, to be attributed to the fact that the English statistics during this period are derived entirely from our town population. From 9 to 15 years the stature of the two branches of our race is the same, and from 16 to 22 it is slightly in favour of the English. At adult life the Americans are a little taller than the English, but the number of the English observations after the age of 22 is not sufficient to determine this point accurately.

'In weight, from the age of 5 to 10 years, the English exceed the Americans, but this is probably to be attributed to the greater weight of the clothes worn by the poorer classes in this country. At 12 the weight is equal; from 13 to 16 it is in favour of the Americans, from 17 to 19 of the English, and after 20 years of the Americans. The number of observations for each age after 16 years of the Americans are too few to be relied on.

'Mr. Gould and Dr. Baxter have shown that, of the recruits for the American Army those born of American parents are taller than those born of English parents, and it has been inferred that a change has taken place in the physical proportions of our race in that country. Dr. Baxter found the average stature of the American-born recruits, between the ages of 30 and 35 years, to be 68·22, the English-born 66·92, and the Irish-born 66·91 inches. But the difference in height is to be explained by the difference in the class from which the recruits were drawn. The English and Irish being emigrants from this country consisted almost entirely of the labouring and artisan class, which we find in this country has an average stature of 66·95 inches; while the American recruits were drawn from all classes of the community by conscription. The average height of all classes in England between the ages of 25 and 30 years is 68·00 inches, and of the corresponding ages in America 68·12 inches, and the slight advantage which the Americans possess is probably due to the very large number of observations (38,055) from which the average is drawn, compared with the very small number of the English (142).

'The averages of the stature and weight of the two great branches of the British race being so nearly alike, I have deduced from them a typical standard of height and weight for the whole British (Anglo-Saxon or Anglo-American) race, which will be found in the 5th column of Tables I. and II. This standard does not consist of any one of the nationalities —English (and Welsh), Scotch, and Irish—of which our race is com-

TABLE III.—Showing the Height (without shoes) of Recruits for the British and American Armies. (All born in Great Britain) :—

Age last Birthday	Recruits for the British Army						Difference		
	England		Scotland		Ireland		England	Scotland	Ireland
	No.	Ins.	No.	Ins.	No.	Ins.	Ins.	Ins.	Ins.
17	560	65·61	134	66·58	176	66·36	The English are the standard of height	0·97	0·75
18	2923	66·69	1000	67·01	1323	66·82		0·32	0·13
19	2122	67·04	538	67·51	725	67·42		0·47	0·38
20	1532	67·08	400	67·76	534	67·14		0·68	0·06
21	1112	67·36	295	67·84	303	67·87		0·48	0·51
22	1000	67·55	263	67·77	305	67·76		0·22	0·21
23	804	67·18	188	68·06	200	67·70		0·88	0·52
24	831	67·80	300	67·95	246	68·02		0·15	0·22
25–30	451	68·15	98	68·09	138	68·39	0·06	—	0·24
Total for 1862–3, Minimum standard 66·0 inches	11,335	67·16	2316	67·62	3950	67·50	—	0·46	0·34
Total for 1864–5, Minimum standard 65·0 inches	2068	66·99	559	67·41	1517	67·25	—	0·42	0·26
American recruits of British birth	16,196	66·57	3476	67·06	50,537	66·74	—	0·49	0·17
British recruits are taller than American of the same nationality by	—	0·50	—	0·46	—	0·63	—	—	—

TABLE IV.—Showing the Weight of Recruits for the British Army (without clothes) :—

Age last Birthday	Recruits for the British Army						Difference		
	England		Scotland		Ireland		England	Scotland	Ireland
	No.	Lbs.	No.	Lbs.	No.	Lbs.	Lbs.	Lbs.	Lbs.
17	560	124·5	134	122·5	176	123·6	2·0	The Scotch are the standard of weight	1·1
18	2923	130·3	1000	126·4	1323	129·7	3·9		3·3
19	2122	133·5	538	131·7	725	134·8	1·8		3·1
20	1532	136·5	400	133·6	534	138·5	2·9		4·9
21	1112	138·5	295	133·4	303	140·0	5·1		6·6
22	1000	139·9	263	134·2	305	141·1	5·7		6·9
23	804	142·2	188	135·1	200	140·0	7·1		4·9
24	831	141·5	300	135·9	246	143·2	5·6		7·3
25–30	451	142·5	98	137·1	138	143·9	5·4		6·8
Total for 1862–3 .	11,335	136·6	3216	132·2	3950	137·2	4·4	—	5·0
Total for 1864–5 .	2068	137·9	559	138·9	1517	138·0	—	1·1	−0·9
							3·3		4·1

posed, but of all three in various proportions. In my statistics the English predominate; in the American, Irish blood must be very largely represented, and there is a large admixture of the Scotch element in both. In order to distinguish the relative stature and weight of the three nationalities I have had recourse to the army returns of both countries, and the results are given in detail in Tables III. and IV. (as shown on preceding page).

'These tables show that the English (and Welsh) recruits are shorter in stature than the Irish by 0·30 of an inch, and the Scotch by 0·44 of an inch; and the American recruits *born in Great Britain* are about half an inch shorter in stature than those of corresponding nationality in the English army.

'The Scotch recruits in Great Britain though possessing the greatest stature, are lighter in weight than the English (and Welsh) by 3·3 lbs., and the Irish by 4·1 lbs., and the Irish are nearly 1 lb. heavier than the English.

'Lowering the standard of height from 66 inches in 1862–3 to 65 inches in 1864–5 lowered the average stature of the English by 0·17 inch, of the Scotch by 0·21 inch, and of the Irish by 0·25 inch; but there was an increase of weight in all three nationalities. In the Scotch it amounted to 6·7 lbs.

'It is probable that the stature of the English recruits is lowered by a large admixture of Welsh, and by the young musicians, who are almost entirely of English birth and often under the standard height.

'3. *The relation between the height and weight of the two sexes of the British or Anglo-Saxon race.* (Chart tracings No. 3; tables I. and II., columns 5 and 6.)

'My statistics of the height and weight of females in England are very limited in extent (from 8 to 14 years of age), and refer only to the labouring and artisan class. As the average male population of England and America are so nearly identical, we may accept the measurements of American girls published by Dr. Bowditch as applicable to this country also. These were collected in the common schools in Boston and surrounding neighbourhood, under the same circumstances and at the same time as the males, and fairly represent the general population. They are given in column 6 of tables I. and II., and the tracings are shown in diagrams 3 and 4. The observations at the time of birth are English, collected by myself, but all the remainder are American.

'At birth girls are about $\frac{1}{3}$ of an inch shorter than boys, and from 1 to 4 there is a much wider difference, but the statistics are too few to determine the amount. From $5\frac{1}{2}$ to $10\frac{1}{2}$ the stature of the two sexes is nearly the same, the advantage being slightly in favour of the boys; but after the age of $11\frac{1}{2}$ and up to $14\frac{1}{2}$ years the girls are the taller; at $12\frac{1}{2}$ the difference is 0·84, and at $13\frac{1}{2}$ 0·88 of an inch. From $15\frac{1}{2}$ to $18\frac{1}{2}$ the growth of the boys is much greater than that of the girls. At 15 the difference in favour of the boys is 1·06 inches; at 16, 3·02 inches; at 17, 4·10; and at 18, 4·85 inches, at which age the females probably attain their full stature. (Chart tracings No. 4; tables I. and II., columns 5, 6, 7, and 8.)

'In considering the weight of the two sexes, we find that at birth girls are $\frac{1}{3}$ lb. lighter in weight than boys; at 5 and 6 the difference amounts to about 6 lbs., but after the latter age the weights gradually approximate, and at 12 they are identical. From $12\frac{1}{2}$ to $15\frac{1}{2}$ the girls are heavier than the boys, the difference at $13\frac{1}{2}$ being 4·52 lbs., and at $14\frac{1}{2}$, 5·02 lbs. At

15½ the weight of the two sexes is again identical, and after this period the excess is largely on the side of the boys; at 16½ it is 7·73 lbs., at 17½, 13·85 lbs., and at 18½, 19·27 lbs.

'As M. Quetelet's tables are the only complete series of observations on the height and weight of both sexes, and at all ages, we possess, and as they have been generally accepted by anthropologists and physiologists as reliable standards, especially at ages below the adult period of life, I have added his figures to my tables, and traced their relation to the British statistics on the diagrams 3 and 4, for the purpose of comparison. M. Quetelet does not state the number of observations on which his tables were based, but they were few ("peu considerable." "Anthrop." p. 182); and probably did not exceed ten individuals for each age ("Anthrop." p. 24); moreover, the measurements were made on persons "regularly formed," and therefore to a certain extent selected. It is necessary to bear these facts in mind in estimating the value of M. Quetelet's tables as standards of reference, and when comparing them with the English and American tables based on many hundreds of observations for each age. M. Quetelet does not state whether the values for each age are for the birthday or for the interval between two birthdays, and I have therefore arranged them like the British, as representing the age between two birthdays. This is important, as bearing on the absolute height and weight, but not on the curves of growth. In the tracings on diagrams 3 and 4 the lines representing the Belgians would be one division of the scale nearer to the lines representing the English if the figures represent the birthdays, but the relative position of the various curves would remain the same. If M. Quetelet's figures represent the heights and weights of the birthdays exactly, there is a difference of half a year in favour of the British at all ages after that of birth.

'The curves show that growth in height is greater in the British from birth to 5 years than in the Belgians. From 6 to 12 years the curves approximate, and the difference is two-thirds less than it was at 5 years of age. From 13 to 17 years the growth of the British is much more rapid than that of the Belgians, the difference in stature at the latter age being about four times greater than it is at 12 years. At adult life the difference in height of the males of the two countries is nearly 2 inches, while the height of the females is the same in both. The most marked differences of the height of the two peoples, is in the relation of the two sexes, the British girls being taller than boys from 11 to 14 years, while the Belgian females are shorter than the males throughout their lives.

'The curves of the weight of the body in the two countries are very similar, except that the weight of the British girls from 12 to 15 is greater than that of the boys of the same ages, whereas the weights of the Belgians of both sexes are the same at 12, but at all other ages the females are lighter than the males.

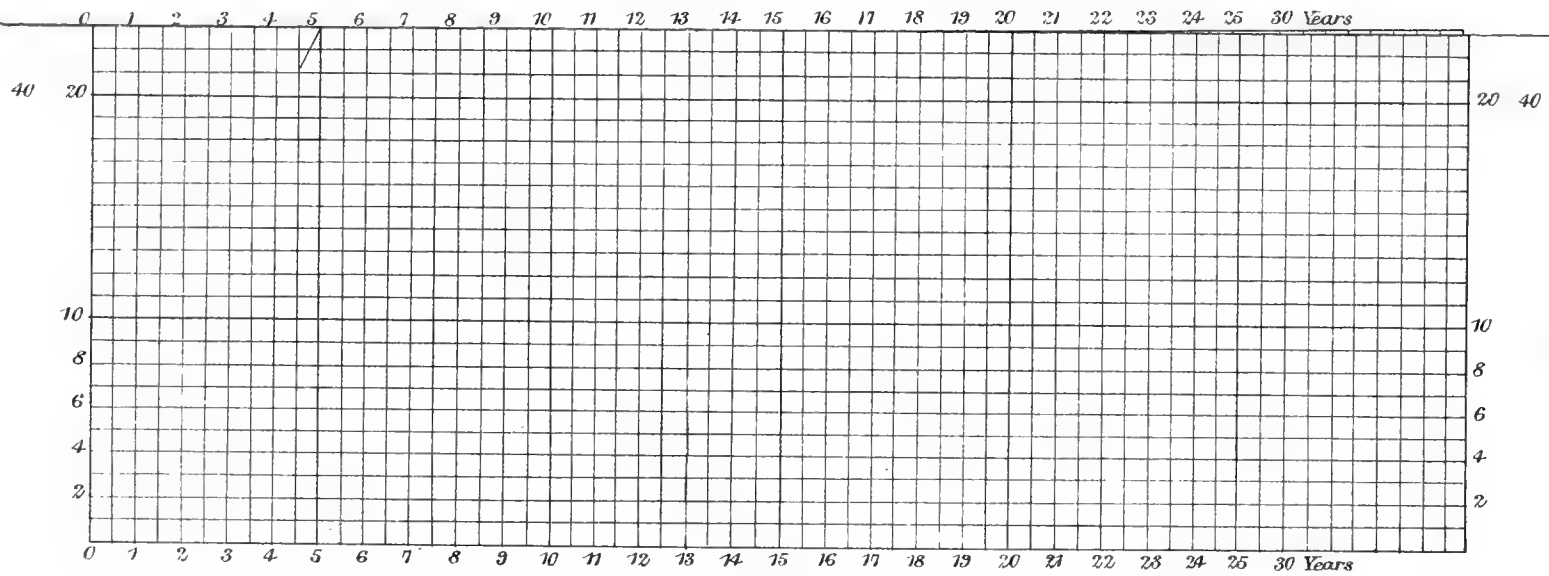
'The differences between British and Belgian statistics cannot be attributed to differences in race, as they are not uniform throughout, and we must consider M. Quetelet's tables, based as they are on so small a number of observations, rather as approximations or estimates of the stature and weight of his countrymen. The difference in the height and weight of the sexes, which was first pointed out by Dr. Bowditch ("Boston Med. and Surg. Journal," 1872), has quite escaped the notice of M. Quetelet, although he has published some British statistics, which demonstrate its existence, and it has been confirmed by all the statistics which have been

collected since. The difference is due to the more rapid growth, and the attainment of maturity at an earlier age, of females than males, for we find that the curve representing females between the ages of $11\frac{1}{2}$ to $18\frac{1}{2}$ is almost identical with the curve representing males between the ages of $14\frac{1}{2}$ and $21\frac{1}{2}$ years, these two periods corresponding with each other in the physical development of the two sexes. It is probable that the curve representing males from 11 to 14 years is depressed a little by school life and the earlier occupation of boys than girls, but the chief difference is obviously attributable to the quicker development of girls, as it is found to exist in all classes of the community. The large number of observations included in my tables show that the difference is constant, and it must therefore be accepted as a fact essential to the proper study of the growth of civilised races, no matter from what cause it may arise.'

The attention of the Committee has been directed to the progress of anthropometric research in other countries. The 'Annals of Statistics' for 1878, published by the Minister of Agriculture, Industry, and Commerce of Italy, has two anthropometric papers of considerable interest directly bearing on the subject of this Committee's inquiry. The first is by Dr. L. Pagliani on the development of the human body. Referring to his own work 'Sopra alcuni fattori dello sviluppo umano,' to Dr. Bowditch's investigations as to the growth of children, and to 'Die Entwickelung des Menschen in den der Geschlechtsreife vorangehenden späteren Kindesjahren und im Jünglingsalter (von 7 bis 20 Jahren) in Verhältniss zum Geschlecht, zur Ethnographie und zu den Nahrungs- und Lebens-Bedingungen in Moleschott's Untersuchungen zur Naturlehre des Menschen und der Thiere,' Dr. Pagliani confirms the observation of Dr. Bowditch that up to 10 years of age the stature and weight of children of both sexes present but little difference, though they are always in favour of boys; that from 10 to 15 years of age the difference becomes greater, and is always in favour of girls; and that after 15 the boys reassert their superiority, and are found to be taller and heavier. Dr. Pagliani also confirms Mr. Roberts's observation that the economic condition of the child has much influence on his, or her, weight and stature. In weight and stature alike the children of the labouring classes stand lower than the children of the well-to-do classes. This is the result of a considerable number of observations in Turin, and is fully borne out by the diagram which accompanies the memoir. Signor Cesare Lombroso in his paper 'On the Anthropometry of the Lucchesia and Garfagnana' endeavours to prove from the high stature, black hair, formation of the head, tending to the dolichocephalic, or head of the African type, *i.e.* one with its diameter from side to side notably shorter than the diameter from front to back, the opposite to brachycephalic, and from other distinctive characteristics, that the people of those States come from the old Etruscan race. Both memoirs illustrate in a conspicuous manner the utility and importance of the inquiry which our Committee has undertaken to institute. M. Quetelet's work upon 'Man (Sur l'homme et le développement de ses facultés),' is well known. But at this moment extensive inquiries in the same direction are being made in Germany, the United States, and other countries. Recent political events, moreover, have imparted a fresh interest on questions of races, and if we are able to extend our researches over all the portions of the British Empire, the home of so many races, we may contribute largely

I. DIAGRAM SHOWING THE HEIGHT AND WEIGHT OF THE ENGLISH POPULATION.

Professional Class — Average — Labouring and Artisan Class in Towns.



Height without shoes. Weight including clothes.

Spottiswoode & Co Lith. London

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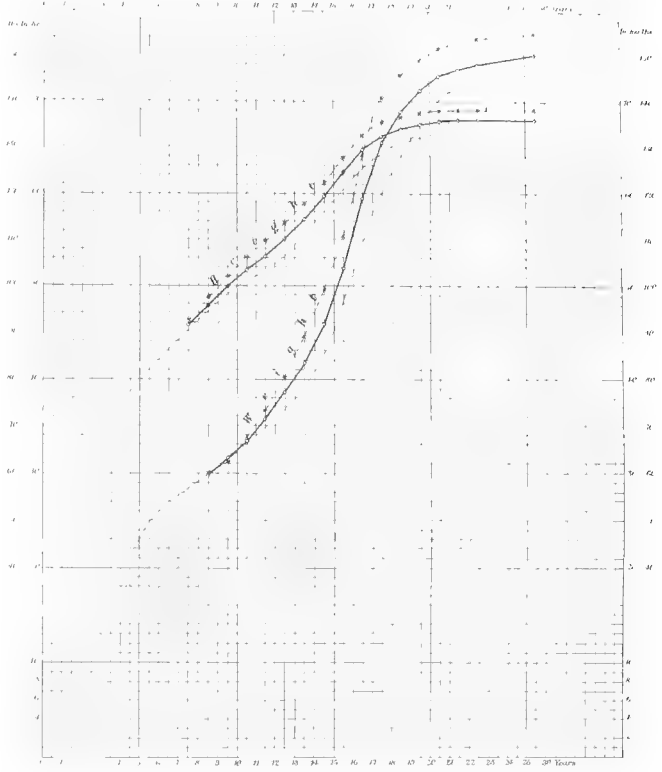
Plate IX.

I DIAGRAM SHOWING THE HEIGHT AND WEIGHT OF THE ENGLISH POPULATION

Professional Class —— Average —— Labouring and Artisan Class in Towns



Height without shoes. Weight including clothes.

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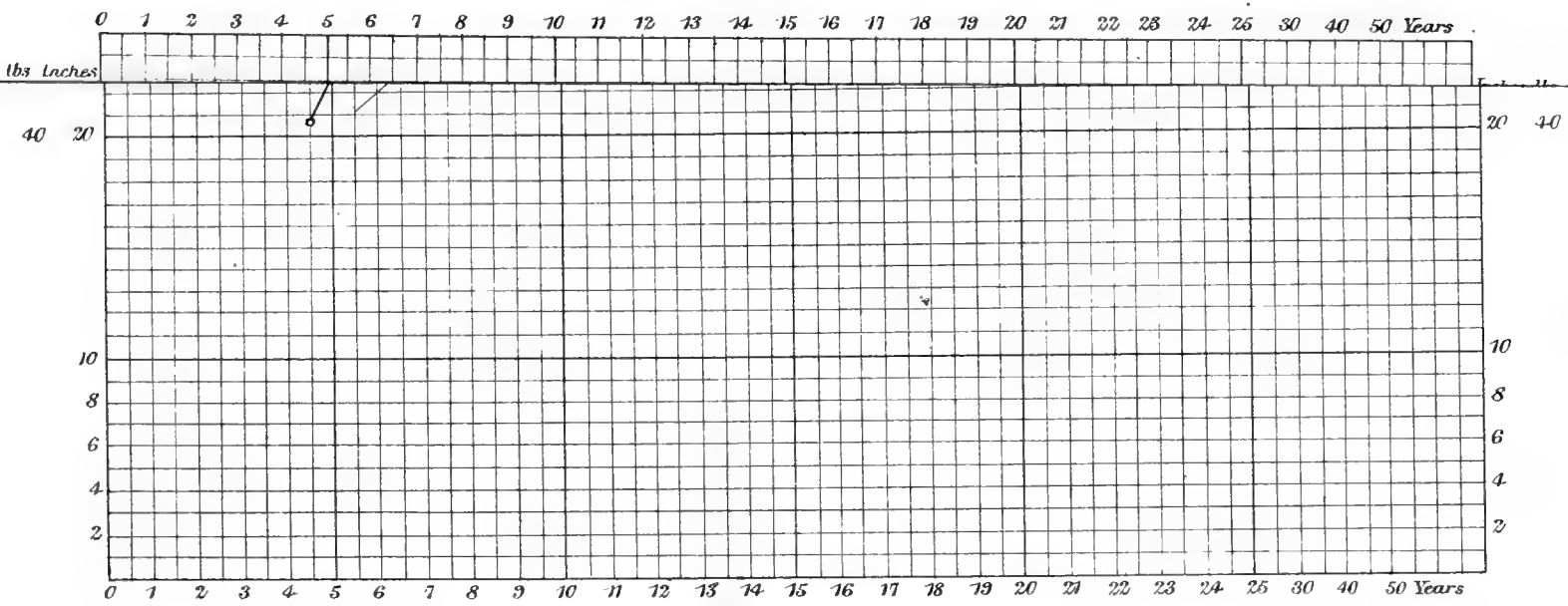
2. DIAGRAM SHOWING THE HEIGHT AND WEIGHT OF ENGLISH AND AMERICAN POPULATION.

—o—o— **English Males** *Roberts* ——— **American Males** *Bowditch and Baxter.*



Height without shoes. Weight including clothes.

Spottiswoode & Co Lith. London.

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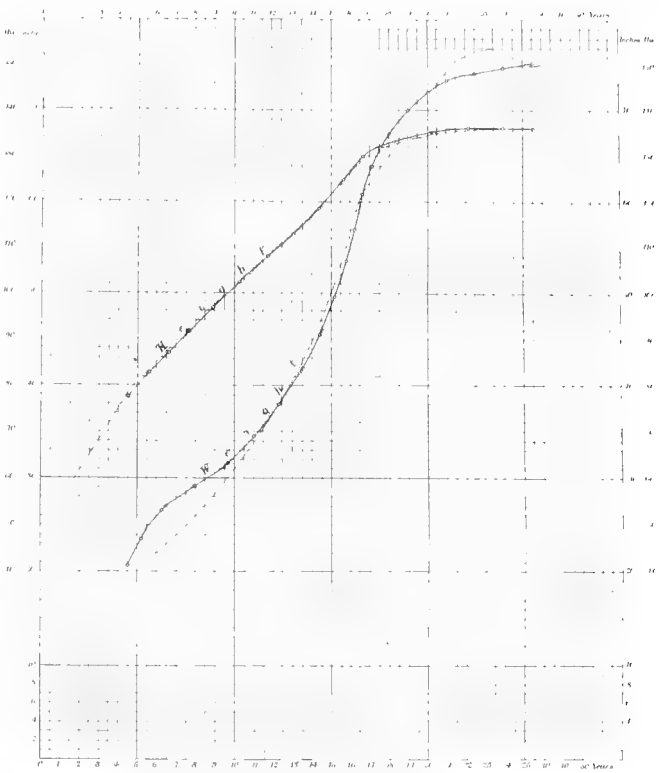
2 DIAGRAM SHOWING THE HEIGHT AND WEIGHT OF ENGLISH AND AMERICAN POPULATION



Height without shoes. Weight including clothes.

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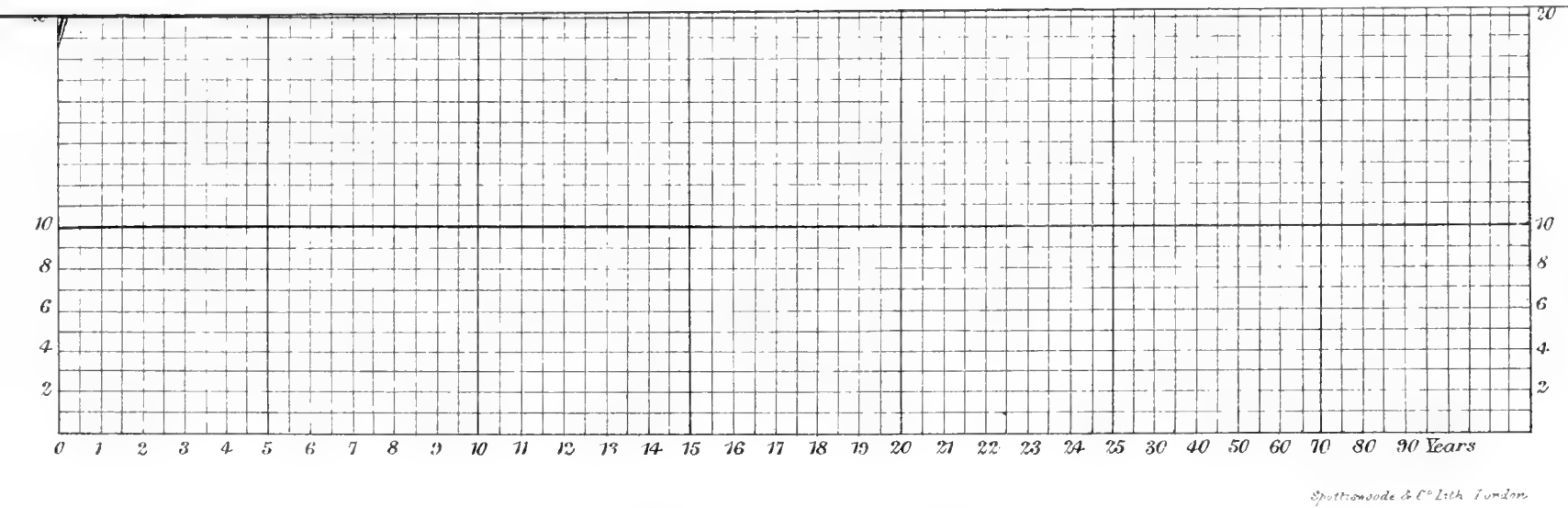
3. DIAGRAM SHOWING THE STATURE OF BRITISH AND BELGIANS OF BOTH SEXES.



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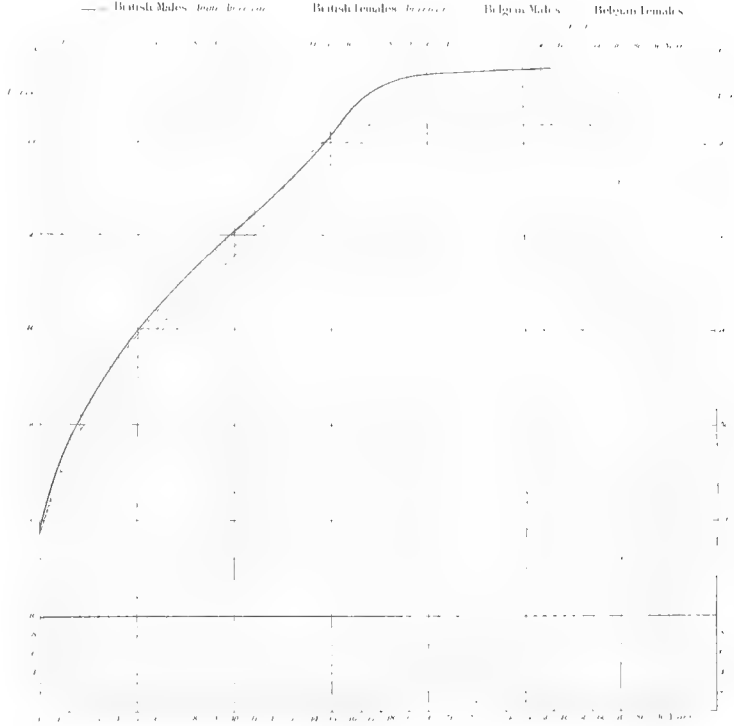
3 DIAGRAM SHOWING THE STATURE OF BRITISH AND BELGIANS OF BOTH SEXES



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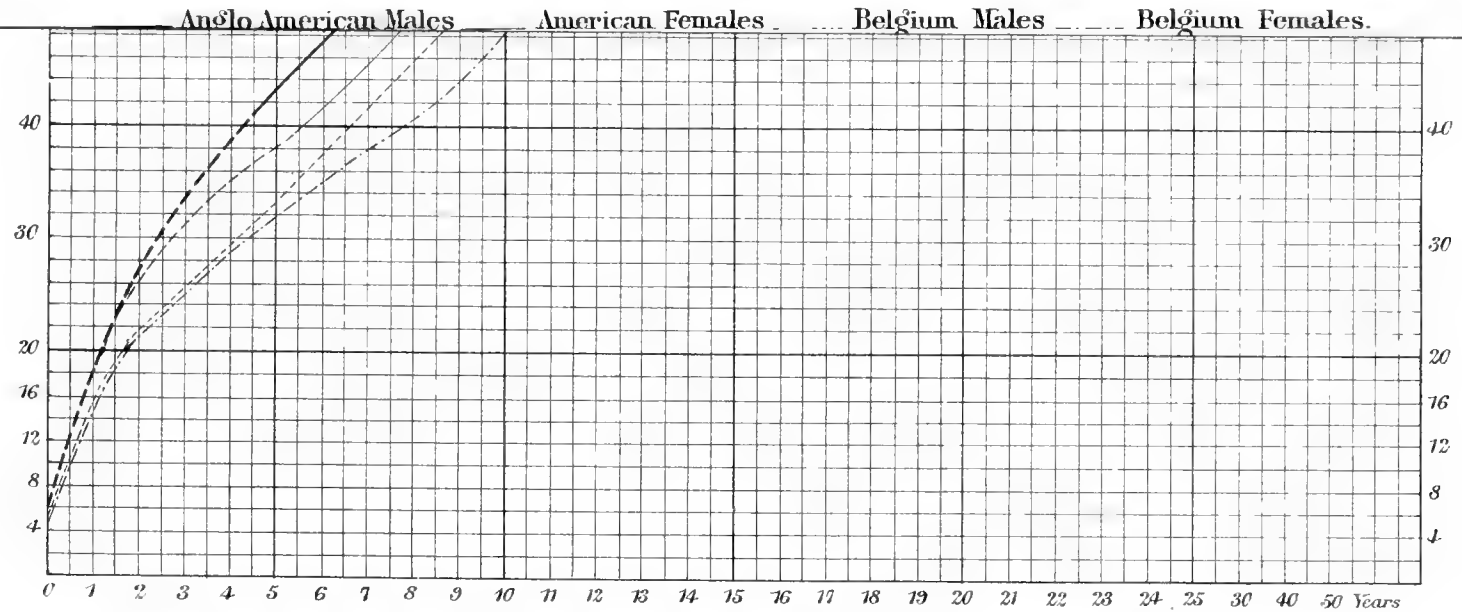
4. DIAGRAM SHEWING THE WEIGHT OF BRITISH AND BELGIANS OF BOTH SEXES.



Note. *The British weights include the Clothes. The Belgium weights probably exclude the Clothes.*

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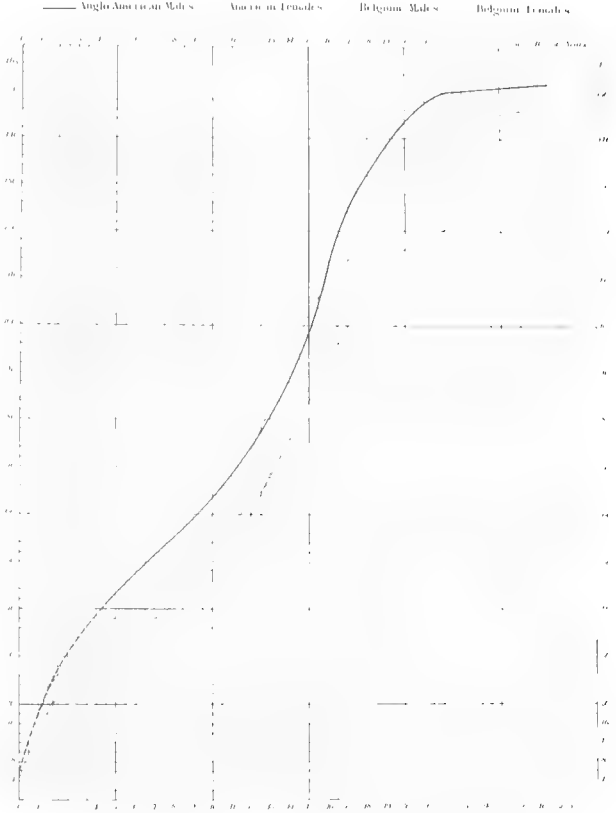
4. DIAGRAM SHEWING THE WEIGHT OF BRITISH AND BELGIANS OF BOTH SEXES



Note. The British weights include the clothes. The Belgian weights probably exclude the clothes.

Illustrations to Report of the Anthropometric Committee

to the amount of general knowledge on the physical and intellectual powers of man.[1]

Professor Bowditch, of Harvard, Mass., has published a supplementary investigation of the growth of children, with suggestions in regard to methods of research, in the 10th Annual Report of the State Board of Health (Boston, 1879). His object was to ascertain whether differences of race or differences in the mode of life affect the rate of growth the more profoundly. The general conclusion he arrives at is that mode of life, as indicated by the occupation of the parents, is equally important with race in determining the rate of growth of children. In his remarks on Anthropometrical methods, Dr. Bowditch reprints, with approval, the forms and instructions which have been issued by this Committee, and recommends the manual and chart prepared by Mr. Roberts. He also advises the use of the card system, extensively adopted in Germany, in which the facts relating to every single person are collected upon a card, which can be combined with other cards in any number of ways, according to the nature of the facts desired to be grouped together. This plan the Committee have resolved to adopt wherever it can conveniently be applied, and a form of card has been drawn up for use by the head-masters of public schools.

A special inquiry has recently been instituted in almost every primary school throughout Switzerland, at the instance of a Committee of the Société des Sciences Naturelles, for the purpose of ascertaining the distribution of the different colours of the iris, hair, and skin, as connected with the settlement of the aboriginal races in that country.

The coincidence of these several inquiries with that undertaken by this Committee is exceedingly interesting, and leads to the hope that, from all these various sources, information of great value may in due course be elicited.

The Committee have made progress during the year in the collection of typical photographs of the inhabitants of the British Islands, and have compiled an album which is exhibited to this section. A sub-Committee has been appointed for Bradford, but has not yet furnished a report. Mr. Sorby, LL.D., F.R.S., has kindly undertaken to assist the Committee in Sheffield with the results of his experience and observation. The Committee hope to continue this branch of their operations during the coming year.

In addition to the collections referred to in the last Report, the Committee have been favoured with several other gifts and loans, and in particular with the loan of a fine collection, comprising 102 Maori and 4 Fijian photographs belonging to Mr. Alfred Eccles, of Torquay, with permission to select from them such as may be suitable for reproduction in a collection of photographic types of the races of the Empire.

The Committee owe thanks to the numerous employers of labour, head-masters of public schools, medical officers of volunteer regiments, public officers, and other persons who have furnished them with statistics, as well as to those who are now engaged in the collection of observations for their use next year.

[1] Communicated by Professor Leone Levi.

Report of the Committee, consisting of Mr. SCLATER, Dr. G. HARTLAUB, Sir JOSEPH HOOKER, Capt. F. M. HUNTER, and Professor FLOWER, *appointed to take steps for the Investigation of the Natural History of Socotra.*

THE Committee have not held any formal meetings, but have been in frequent communication with each other on the subject.

The best time for the exploration of Socotra being from November to March, the Committee were not able to make the necessary arrangements last autumn. Next winter, however, they believe that Colonel H. H. Godwin-Austen, than whom no more competent naturalist could be found, will be able to undertake an expedition to Socotra, and to make a thorough investigation of its natural history. Colonel Godwin-Austen has applied to the Surveyor-General of India for the use of some of the assistants on his staff, and proposes to make a complete topographical survey of the island during the expedition.

It is estimated that the total cost of the expedition will be about £300. Of this £100, granted by the Association last year, has been received by the Committee and deposited in the London and County Bank at interest. The sum of £175, having been devoted to this same purpose out of the Government Fund of £4,000 administered by the Royal Society, has been paid to Colonel Godwin-Austen, and has been added to the account at the London and County Bank.

There remains, therefore, only £25 requisite to complete the sum of £300, which the Committee consider will be required for the expedition.

The Committee request that the Committee for the investigation of the Natural History of Socotra may be reappointed, with the additional name of Colonel H. H. Godwin-Austen, and that the balance of £25 necessary to complete the estimate of expenditure may be placed at their disposal.

Report of the Committee, consisting of Mr. F. J. BRAMWELL, Mr. A. E. FLETCHER, Rev. E. L. BERTHON, Mr. JAMES R. NAPIER, Mr. C. W. MERRIFIELD, Dr. C. W. SIEMENS, Mr. H. M. BRUNEL, Mr. J. N. SHOOLBRED (*Secretary*), Professor JAMES THOMSON, *and* Professor Sir WILLIAM THOMSON, *on Instruments for Measuring the Speed of Ships.*

IT is with feelings of great regret that the Committee have to advert to the death of their chairman, the late Mr. Wm. Froude, M.A., F.R.S. His somewhat sudden demise was a great loss to science, and especially to that branch of investigation—the action of waves upon ships—to which he had devoted himself. His loss must be greatly regretted by the British Association generally, but more particularly by this Committee, since by his death was left incomplete that series of experiments upon those instruments for measuring the speed of ships, which had been referred to this Committee to report upon, and which, at the instance of

the Committee, he most kindly undertook to carry out at the experimenting tank at his house at Torquay.

The result of the first portion of those experiments he presented, through this Committee, to the Association at its meeting at Belfast in 1874. The second and concluding part he did not live to complete.

His son, Mr. R. Edmund Froude, who assisted his father throughout the entire of his first set of experiments, has, however, communicated to the Committee the result of some experiments carried out by Mr. Wm. Froude last year with H.M.S. *Iris*, upon a pressure log, the form of which was in accordance with the conclusions drawn from the first set of experiments, detailed in the Report of 1874.

The results are, it is understood, confirmatory of the views held by the late Mr. Froude.

The Committee deem themselves fortunate to be able to terminate their labours by the presentation of this document as an appendix to this report. They have only to add that having ascertained that the first series of experiments for the Report of 1874 had entailed upon the late Mr. Wm. Froude expenses amounting to 17*l.* 1*s.* 8*d.*, they have refunded that amount to his executors (out of the 50*l.* originally granted to the Committee).

Appendix.

To the Secretary of the British Association Committee on Instruments for Measuring the Speed of Ships.

Chelston Cross, Torquay, 27th July, 1879.

Dear Sir,—In compliance with your request I proceed to give a description of the character and behaviour of the pressure log used in the M.M. trials of H.M.S. *Iris* last summer, in so far as it throws light upon the points suggested for further inquiry in my father's Report to the Committee at the Belfast meeting of the Association in 1874.

In the *Iris* two pressure tubes were used which I will call A and B. Both were $1\frac{1}{2}$ inches external diameter. Tube A finished at the outer end in a gunmetal disc 8 inches diameter, and $\frac{2}{10}$ inch thick, turned in a lathe on both faces nicely flat and square to the axis of the tube. The disc extended completely across the tube end, so as to close it. Tube B was simply plugged up, the plug being turned off square and true to the axis, forming a plain flat end to the cylindrical tube. In each tube was fitted a central tube of smaller diameter. A nice clean hole about $\frac{1}{8}$th inch diameter was drilled in the centre of the closed end of each tube, communicating with the central tube, and a similar hole in the side of each tube communicating with the annular chamber round the central tube. In tube A the side hole was distant 2 inches from the outer surface of the disc, in tube B it was distant 3 inches from the outer surface of the closed end. A cross section of each tube is given above. Each of the two chambers in each of the two tubes communicated with a gauge glass, the level of the water surface in which indicated the pressure in the chamber. There were thus four gauge glasses in all, two communicating with the side holes of the two tubes, two with the end holes.

Both tubes were fixed in the upright side of the ship (of course nicely square to the plating) between 2 and 3 feet below the water level, and a little way abaft the midships. [The *Iris*, it should perhaps be stated, is 300 feet long, 46 feet beam, 18 feet mean draught (on trial). She has

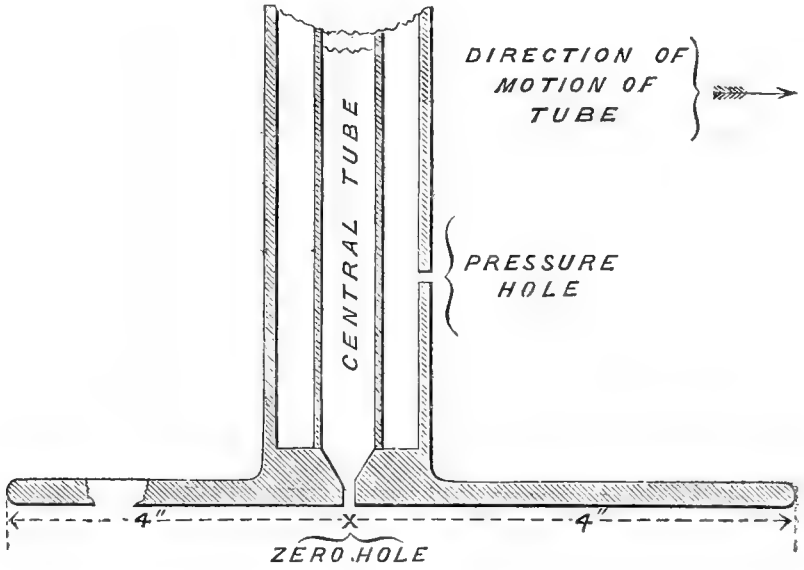


Fig. 1.—Tube A.

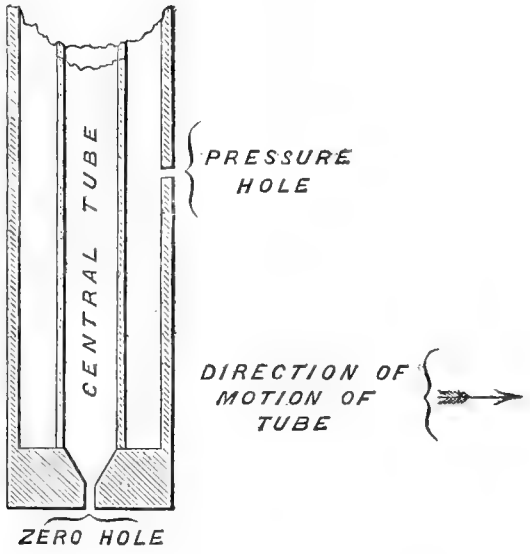


Fig. 2.– Tube B.

Cross-sections of tubes A and B, half size.

exceptionally fine lines for her length, the ratio of displacement to circumscribing cylinder being only ·54.] Tube A was 9 inches further forward, and also 9 inches nearer the water surface, than tube B. Both tubes worked in stuffing boxes, and could be set so as to project any desired distance from the side up to about 23 inches.

The object of the application of a pressure log to the ship was to aid in the determination of the speed during the steam trials; the special object of the use of two tubes and other principal peculiarities of the arrangement just described was to investigate, if opportunity should serve: (1) the effect of distance of pressure hole from the ship's side (in virtue of difference of position in regard to the frictional wake); (2) the extent to which, if at all, the indication given by a pressure hole not far from the end of a plain tube such as tube B, falls short of that given by one in the side of a tube fitted with an end plate or disc, such as tube A; (3) the relative goodness of the measures of general pressure of water (to give the zero of the scale of pressure due to speed) respectively afforded by the hole in the end of the disc-tube A when projected far from the ship's side, and that in the end of the plain tube B when drawn in flush with the ship's side. (That some such arrangement as either of these might fulfil the desideratum of a 'working zero' was suggested in Mr. Froude's Report.) The general method in which the two tubes were to be utilised for the above objects, was to retain one of the two unaltered, as a check on variations of speed or trim of ship, while the desired variations of condition were successively introduced into the other, and the effect noted.

Experiments of this kind could not however be carried on during the runs on the mile, and as a fact circumstances did not admit of the investigation of the points above described except in a very hasty and cursory manner during a preliminary run. During the runs on the mile the disc tube alone was used, retained unaltered, at a projection of 15 inches (to the outer surface of the disc), the side hole being of course used for the pressure, the end hole for the zero. The trials of the ship in which the log was used were made on two different days, there being on each day 8 runs on the mile, namely, 4 at 16 knots, 2 at 12 knots, and 2 at 8 knots.[1] During each run over the mile, the zero of the scale by which the height of column was read off, was held level with the surface of water in the glass communicating with the 'zero' hole, the height of column in the pressure tube being noted by the scale every 12 seconds.

The speed of the ship through the water in any series of measured mile runs in tidal water has of course to be inferred from the recorded times occupied in running the mile, by the aid (explicit or implicit) of some assumptions in respect to the character of the variations of tide that may have been occurring throughout the series of runs. The method of eliminating tidal errors adopted by Mr. Froude in analysing the results of the measured mile runs of the *Iris* would take too long to explain here; suffice it to say that it is clearly as accurate a method as can be found, since it utilises to the full all the obtainable facts.

The information yielded by the experiments generally may be stated as follows.

1. Comparison of speed theoretically appropriate to height of column indicated by log, with speed of ship through water estimated from time running the mile, in the manner above referred to, assigns about ·925 to 1, as the average 'rate' of the log (or ratio of speed of ship to apparent speed by log). The results are not inconsistent with the supposition that the 'rate' was uniformly ·925 at all speeds; but are

[1] Four runs were also taken on each day at full speed (about 18½ knots), but the log could not be used in these.

more consistent with the supposition of a variation of rate at different speeds from about ·91 to ·93. The impossibility of making a more definite statement than this is an example of the impossibility of 'rating' a log very correctly for different speeds, by runs on the measured mile in a tideway, except by means of a great number of runs.

2. The instrument did not appear very sensitive to the effect of variations in distance of pressure aperture from the ship's side, at any rate when such distance exceeded one foot.

3. The pressure hole in the side of the plain tube B gave little if at all less height of column than that in the disc tube A. (This agrees with proposition (3), page 257, in the 1874 Report.)

4. The 'zero' holes in the ends of tubes A and B both gave the same height of column when tube B was, not flush with the ship's side, but projecting about 2 inches; the column given by tube B when flush with the side being the greater of the two by perhaps 2 per cent. of the whole head due to the speed of the ship at the time. There was no means of testing which of these two 'zero' holes (or whether either) gave the correct zero of pressure. As speed increased both sank somewhat, relatively to a fixed point in the ship, but whether more or less than the water outside the ship was not ascertained. I am myself doubtful whether the excess of pressure given by the zero hole in tube B, when flush with the ship's side, relatively to that given by the zero hole of the disc-tube A, is a genuine excess of pressure on the former due to some action of the frictional eddies, or a genuine defect of pressure on the latter due to the tube being possibly not dead square to the side (the disc consequently moving somewhat obliquely through the water). An error of squareness of the tube to the ship's side of 1° (pointing sternward) would, perhaps, have been competent to produce the observed effect.

Now, as to the information afforded by these results on the points suggested by the 1874 Report, as needing solution.

The treatment of the subject in that Report suggests a division of the question into two, namely (1), the operation of the pressure log regarded simply as a measure of its own speed in reference to the water it passes through (the foremost difficulty here involved being that of establishing a 'working zero' for the instrument); (2), in what way its operation as an independent measure of the ship's speed through the water is affected by the motions impressed by the passage of the ship on the fluid she displaces; in other words, by the difference between the speed of the instrument through the water it meets with and the speed of the ship in reference to the surrounding ocean.

The Report described a series of experiments which dealt only with question No. (1), and stated that the investigation of question No. (2) might perhaps be introduced as a part of the methodical series of experiments on resistance of ships which Mr. Froude was conducting at Torquay. The investigation would certainly be of great value in reference to the general question of resistance of ships; but the pressure of other work has, I regret to say, prevented its being undertaken.

Of the results obtained in the *Iris*, and which I have above enumerated, Nos. (3) and (4) are pertinent only to question No. (1), namely, the performance of the instrument regarded as a measure of its own speed through the water it meets with. I think they show that a hole in the side of a tube, as much as two diameters distant from its end, will furnish as good a measure of pressure due to the speed of flow past it

as can be wished; and that a small hole in the closed end of another tube, flush with the ship's side, will furnish at any rate a very tolerable working zero.

The results I have numbered (1) and (2) are, so far as they go, pertinent to question No. (2), namely, the effect on the indications of the log, produced by the motions caused by the ship in the surrounding water. The information they afford is, however, very slight, as I will proceed to show.

The motions caused by the ship in the surrounding water are twofold, namely, the frictional wake, and the stream line (or quasi-stream line) motions. On the frictional wake part of the question, the experiments which were intended to be made in the *Iris* (as stated in paragraph 4, above), on the effect on the pressure column of distance of the pressure hole from the ship's side, would have given most important information, had the trials of the ship permitted of their being properly carried out. The hasty observations actually made, though sufficient to show that the pressure hole, at a distance of a foot from the side, is clear of the extreme ardency of the frictional wake, do not inform us how far it is necessary that the pressure hole should be from the ship's side (at any given distance from the bow of the ship), in order for it to be altogether clear of the wake. Yet if it is not altogether clear of it, the instrument cannot be a permanently satisfactory measure of the speed of a ship which has to remain long afloat, because any fouling of the ship and consequent increase in skin friction, must increase the speed of frictional wake at given speeds and given distance from the ship's side, and consequently diminish the pressure indicated by the log at given speed.

With reference to the more complicated question of the effect of the stream line or quasi-stream line motions upon the 'rate' of a pressure log, the measurement of the 'rate' (as by these experiments) in the special case of the *Iris*, with the log in the single position in which it was tried, is of small general value. The experiments which Mr. Froude contemplated making in reference to this point, referred to in the 1874 Report, were to be of the nature of the application of a pressure log to a great variety of models of ships in a great variety of positions. I do not think that Mr. Froude expected that the information so obtained would do more than enable us to so place the log in any given ship, that its 'rate' should be *approximately* predeterminable and so far uniform for all speeds, that it could be 'rated' with sufficient accuracy for ordinary sea-going purposes by a few runs at one speed on the measured mile.

In the absence of these special experiments, our present knowledge of the phenomena attendant on the passage of a ship through water may be brought to bear advantageously on the question of the right place in the ship for a pressure log; and as I have had the advantage of frequently discussing the subject with Mr. Froude, and had other opportunities for its special study, in connection with our experiments on Resistance, I may be permitted perhaps to add a few words in reference to it.

At low speeds in smooth water, when the surface of the water surrounding a ship is visibly quite undisturbed by waves caused by her movement, it cannot be doubted that the motions taking place at various points in the surrounding water are simply those which would take place in the same positions relatively to a symmetrical submerged body the lower half of which was similar to the immersed hull of the ship.

It is an accepted proposition of the stream line theory that the stream lines surrounding a submerged body are similar in character at all speeds, the speed of stream at any one point in the system bearing at all speeds the same proportion to the speed of the submerged body. We may assume then that as with a submerged body so also with a ship moving at the surface of water, the speed of stream at any given point with reference to the ship (except in the purely frictional wake perhaps) will be proportional to the ship's speed, at all speeds up to that at which sensible waves commence to be formed. This would, moreover, continue to be the case at higher speeds could the water surface be forcibly kept level by a water deck (for instance) surrounding the ship in all directions, at the level of her water-line.

Put then a pressure log where you will, its 'rate' will under the supposed conditions be constant for all speeds.

In the actual case of a ship without the imaginary water deck, the 'rate' will be in the same manner constant at all low speeds, and will at higher speeds vary with varying speed only in virtue of the introduction of the new set of fluid motions appropriate to the wave system which begins to accompany the ship at higher speeds, and which essentially varies in its character with varying speed.

The predominant characteristics of the wave system which thus comes into play at the higher speeds may be roughly noted, so far as pertinent to the pressure log question, as follows:—

(1) The wave system may be divided into two distinct series, the transverse and the diverging, in the former of which the line of crest is nearly square to the line of motion, in the latter trailing backwards at an angle of forty or fifty degrees.

(2) The waves (of the diverging series particularly) are comparatively short along the line of crest, and die away gently into the level water at the ends.

(3) Each series of waves is a continuous series, which, though it has an abrupt commencement at the bow of the ship,[1] has no definite termination, but extends away backwards wave behind wave, the waves only very gradually diminishing in height as they lengthen along the crest.

(4) In the transverse series the waves are placed directly one behind the other, or nearly so, so that in a ship with very long parallel sides the crests of the waves may be seen in cross section against the side repeated one after the other. In the diverging series, on the contrary, a line drawn from the highest point of each wave crest to the highest point of the next, and from that to the next, and so on, intersects the lines of the crests at an angle much sharper than the angle contained between the lines of the crests and the line of motion of the vessel. The consequence of this arrangement is that none of the diverging series of waves touch the side of the ship at all, with the exception of the first member of the series, which has its highest point near the stem of the ship (and in some cases the second member also in a very small degree).

(5) The system of proper local motions of the water composing the waves probably resembles that recognised as appropriate to ocean waves,

[1] I am speaking here only of waves originating at the entrance of the ship, and which are the only ones very important in reference to the pressure log question; but it is worth noting that a very similar set of waves, of both transverse and diverging character, originate at the run of the ship also, the two sets of transverse waves (*i.e.* the bow set and the stern set) becoming fused into one joint series.

namely, a forward motion under the crest and a backward motion under the trough, though these local motions clearly cannot be supposed in the leading members of the system to penetrate the water so deeply as in properly formed ocean waves.

(6) The transverse waves are necessarily much longer (measured normally to the line of crest) than the diverging waves, and their proper motions therefore probably penetrate much the more deeply of the two. (In ocean waves the wave motion at a depth equal to about one-ninth the wave depth is held to be about half that at the surface.)

(7) The diverging wave system is well marked at moderate speeds, at which the transverse system scarcely appears. When, however, the speed of the ship becomes high in comparison with her length of entrance, the transverse system comes rapidly into prominence.

(8) The lengths of the waves (that is, their distance apart measured normally to the crest line) vary as the square of the speed, and as the leading wave crest remains always at the bow of the ship, change of speed changes considerably the fore and aft positions of the subsequent members of the transverse series relatively to fixed points in the side of the ship, this rate of change of position increasing with distance sternwards.

The general effect of the wave system upon the 'rate' of a pressure log fixed, near the water surface, amidships in a ship with long parallel side will, then, be somewhat as follows. At moderate speeds at which the transverse wave series does not come into play, the effect of the wave system on the log will be *nil*, and the 'rate' will be the constant 'rate' due to the stream line motion at its position. As the speed increases and the transverse waves appear, and lengthen out with increasing speed, the log indication will be alternately increased and diminished relatively to the true speed, according as the speed reached brings trough or crest over it. This kind of result would clearly be almost the most inconvenient imaginable,[1] and though I have supposed an extreme case, the evil would in most cases partake of the character I have sketched.

The most objectionable feature in this supposed result is clearly due to the change of position of the wave features relatively to the logs which accompanies change of speed, and the magnitude of this evil is clearly lessened generally speaking by putting the log as far forward as possible, and therefore closer to the bow wave, the stationary or datum point of the system, but by so doing it will be rendered more subject to irregularities in its action due to pitching of the vessel. I am inclined to think that underneath the position of the first wave-trough at a little under the full speed of the ship would generally give about the best result, and I consider this position (independently of the pitching question) preferable to the back slope of the bow wave, for although the absolute effect of the wave on the indication of the log would be more in the former position than in the latter (in fact on the midslope it would be *nil*), the *change* of wave position due to change of speed would produce a more changing effect (and cause a more rapidly changing 'rate') in the latter position than the former.

It is of course advisable to put the log as deep as possible, and indeed

[1] It did not indeed appear noticeably in the *Iris*, although the log was, as has been stated, amidships and quite close to the water surface; but she is a ship with nothing resembling parallel sides, and makes no transverse waves of importance until she comes to making a single wave from end to end, with the trough amidships.

a log near the keel of the ship would be altogether out of the depth of the effect of the diverging waves, though not of the transverse waves, except perhaps in deep slow ships.

To rehearse briefly the statements and line of argument of this communication.

(1) The behaviour of the pressure log in H.M.S. *Iris* showed that a pressure hole in the side of a $1\frac{1}{2}$ inch tube, and 3 inches from the end, gave substantially the same pressure reading as one in the side of a similar tube fitted with a disc at the end, such as that above described as tube A.

(2) The *Iris* pressure log results further show that either a small hole in the end of a tube with a disc such as tube A, when projecting from a ship's side; or again a small hole in the end of a plain tube, such as tube B, set with the end flush with the ship's side, will furnish a very serviceable 'working zero' for the pressure column.

(3) Though the *Iris* results show that at a distance of 150 feet or so from the bow of a ship a pressure hole more than one foot distant from the ship's side may be accounted as clear from the extreme ardency of the frictional wake, it remains to be tested how far distant from the side a pressure hole need be (at any given distance from the bow) in order to be so far clear from the frictional wake that the instrument may be accounted as unaffected in 'rate' by the degree of cleanness of the skin of the ship.

(4) There is an absence of direct experimental data generally applicable to all cases, as to the effect on the 'rate' of a pressure log, of the 'stream line' (or quasi-stream line) motions of the water surrounding the ship. Variability of such 'rate' with varying speed is clearly a much greater evil than absolute greatness of such 'rate,' as involving great additional difficulty in correctly ascertaining its value for a given ship at all speeds by means of M.M. 'Trials.' Our general knowledge of the fluid conditions essential to a ship's progress through the water are so far of assistance to us, in the absence of proper experimental data, in that it shows pretty clearly (*a*) that '*stream line*' *motions proper*, *i.e.* those due to motion of a submerged body (or a ship at the surface at low speeds) would cause a 'rate' of log constant for all speeds; and that varying speed will produce varying 'rate' only in virtue of the formation of surface waves; (*b*) that to avoid the variability of 'rate' with varying speed, introduced by the wave system, the best plan appears to be to fix the log as deep below the surface as possible; and, in fore and after position, vertically under the position of the first wave-trough at rather less than the full speed of the ship.—I remain, dear sir, yours faithfully,

R. Edmund Froude.

Third Report of the Committee, consisting of Professor Sir WILLIAM THOMSON, Major-General STRACHEY, Captain DOUGLAS GALTON, Mr. G. F. DEACON, Mr. ROGERS FIELD, Mr. E. ROBERTS, *and* Mr. J. N. SHOOLBRED (*Secretary*), *appointed for the purpose of considering the Datum-level of the Ordnance Survey of Great Britain, with a view to its establishment on a surer foundation than hitherto, and for the tabulation and comparison of other Datum-marks.*

[PLATE XIII.]

APPOINTED in 1875 at the Bristol meeting, to inquire into some uncertainties as to the exact position of the Datum-level of the Ordnance Survey of Great Britain, the Committee presented in 1877, at the Plymouth meeting of the Association, a Report upon the subject.

At the conclusion of that report, the Committee requested to be reappointed 'in order to obtain information as to some of the various local datum-marks in use in the British Isles, and to endeavour to ascertain the difference of each relatively to the Ordnance datum; which would thus become a means of comparison between them.'

The Committee beg to present, as an appendix to this Report, a list of about fifty local datum-marks in Great Britain; the connection of each of which has been obtained on reliable authority. In Ireland the position of some datum-marks there relatively to the datum of the Ordnance survey of that country has also been ascertained.

On the assumption that the mean sea-level, as given in the book of Ordnance levels of the respective countries, is uniform across the Irish Sea, the difference between the systems of levels in use in the two countries has been computed. In a similar way also has the difference been ascertained between the Ordnance datum of Great Britain and the official datum in use in France (Zero du Nivellement général de la France—ligne de Bourdaloue); and, through it, with the official levelling in Belgium and in Holland. Several local datum-marks in these countries have been obtained, each with the connection with the Government levelling of its own country.

The Committee trust that this list may serve as a basis, which may be further extended, and become a means of obtaining accurate comparative levels, not merely for engineering and other levelling operations, but also for the connection of tidal observations round our coasts. On the assumption already mentioned, of an uniform sea-level, tidal observations on the adjoining coasts of Ireland and of the Continent may also be included.

The question of a suitable datum-level as a basis for these international tidal observations, has been considered by the Committee. A level which, while sufficiently low, so as to exclude negative readings, shall bear an easily found relation to the respective datum-marks of the different countries, is requisite for the purpose.

It is found that, with the differences given in the list appended, a level of '20 ft. below the Ordnance datum of Great Britain' coincides (to within 0·01 metre, or $\frac{3}{8}$ in.) with '5·50 metres below the French Zero du Nivellement;' and also to '12 ft. 6 in. below the Ordnance datum of Ireland' (to within 0·04 ft., or $\frac{1}{2}$ in.). This level has, moreover, the advantage of being below the range of almost all the tides

round our coasts, excepting the low water of a few equinoctial springs at two or three points, such as in the River Severn near to the mouth of the Avon, and in the Bay of St. Malo on the coast of France.

In conclusion, the Committee beg to add, that the 10*l.* granted to it has been expended; in expenses, in connection with levelling to ascertain the exact relative position of the Ordnance datum of Great Britain, and in correspondence and in other matters in the preparation of the list of local datum-marks appended hereto.

APPENDIX.—List of various Local Datum Marks in use in the British Isles, with difference of each from the Ordnance Survey Datum Level.

ENGLAND.				
Ordnance Datum of Great Britain	Mean Sea Level at Liverpool, from Observations taken in 1844 by Ordnance Survey Department	Ordnance Datum of Great Britain		Authority
		Feet Above	Below	
Trinity H.W. Standard (River Thames)	H.W. mark on east side of Hermitage entrance of London Docks.	12·50	—	J. N. Douglass.
Avonmouth .	Inner sill of lock, Bristol Port and Channel Dock.	—	7·5	J. Brunlees.
Barrow . .	Outer sill of Ramsden Dock . .	—	17·25	F. C. Stileman.
Birkenhead .	Outer entrance to Alfred Dock (12 ft. below O.D.S.).	—	16·67	G. F. Lyster.
Boston . .	Black sluice sill (91·30 ft. above, 100 ft. below Ordnance).	—	8·7	W. H. Wheeler.
Bristol . .	Sill of Cumberland Basin . .	—	10·58	T. Howard.
Cardiff . .	Sill of sea gates of Bute Dock. .	—	10·72	J. McConnochie
Dee . .	Zero of tide-gauge, Chester. (Dee standard is 15 ft. above zero of this tide-gauge).	1·38	—	G. A. Bell.
Devonport .	Sill of New Long Dock . . .	—	—	S. L. Churchward.
Dover . .	Zero of tide-gauge at Admiralty Pier	—	8·70	E. Druce.
Ellesmere Port	Sill of Entrance Dock (6 ft. above O.D.S.)	1·13	—	Captain G. H. Hills, R.N.
Fleetwood .	Datum of New Docks . . .	—	12·00	Sir J. Hawkshaw.
Garston . .	Sill of Old Dock	—	9·58	J. N. Shoolbred.
Goole . .	Lower sill of Outer Ship Lock. .	—	3·82	W. H. Bartholomew.
Goole	Datum of Admiralty Chart (2 ft. 8 in. on sill of Ship Lock).	—	1·66	Captain E. K. Calver, R.N.
Grimsby. .	Datum of Admiralty Chart . .	—	9·55	Captain E. K. Calver, R.N.
Hartlepool .	Old Dock sill	—	13·36	J. Howkins.
Harwich. .	Zero of tide-gauge	—	7·0	A. A. Langley.
Holyhead .	Zero of tide-gauge (tidal observations, 1875).	—	10·45	Sir J. Hawkshaw.
Hull . .	Humber Dock sill	—	14·33	R. A. Marillier
Hull . .	Datum of Admiralty Chart . .	—	9·45	Captain E. K. Calver, R.N.
King's Lynn .	Free Bridge datum, zero of gauge (mean of Ordnance B.M.'s).	—	4·95	Rogers Field.

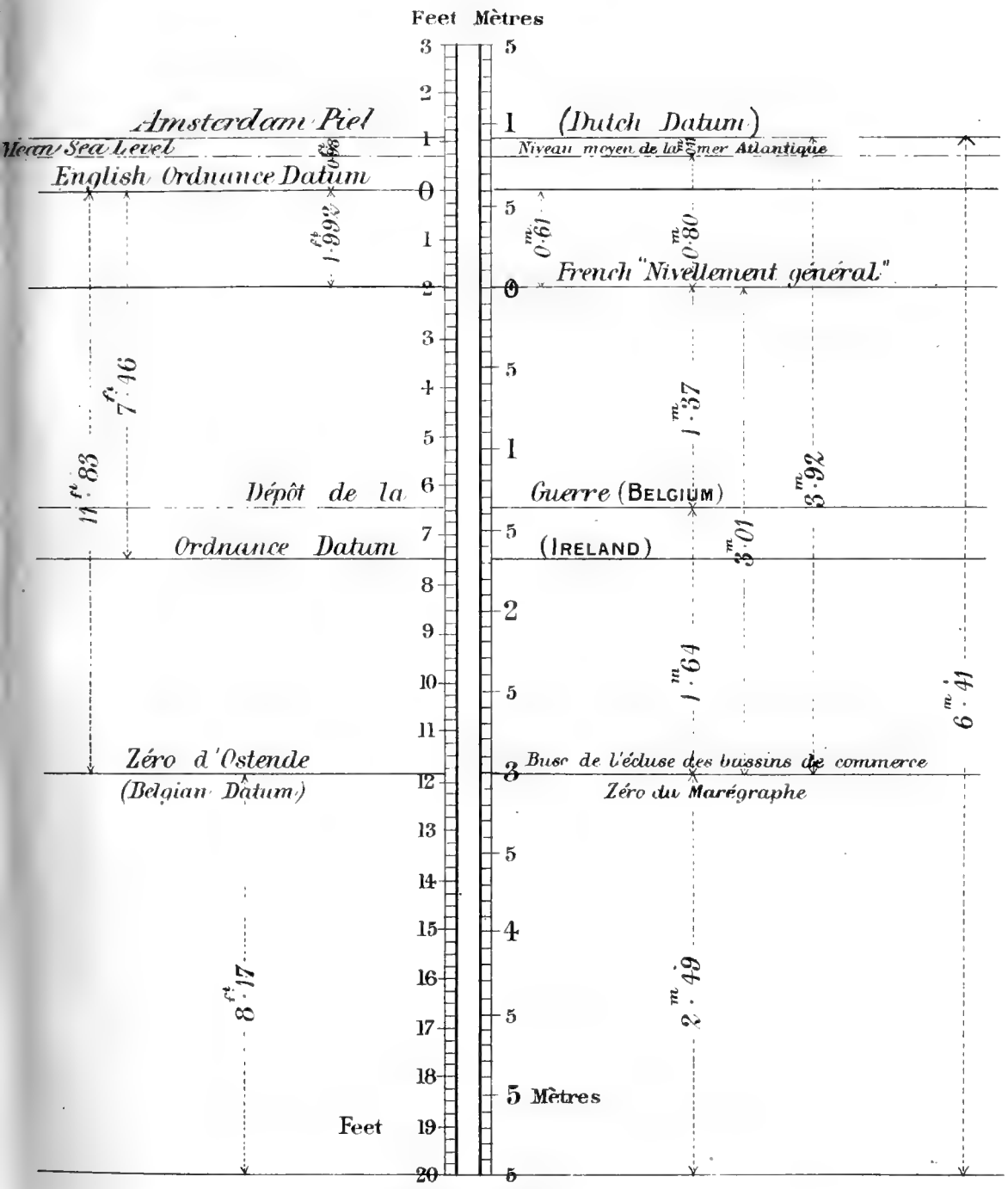
LIST OF VARIOUS LOCAL DATUM MARKS, &c.—*continued.*

Ordnance Datum of Great Britain	Mean Sea Level at Liverpool, from Observations taken in 1844 by Ordnance Survey Department	Ordnance Datum of Great Britain		Authority
		Feet Above	Feet Below	
ENGLAND—*continued.*				
Liverpool	Level of Old Dock sill datum (Canning Island gauge).	—	4·67	Ordnance Survey.
Lowestoft	Zero of tide gauge	—	13·5	A. A. Langley.
Nene Valley	Ordnance B.M. cut into quoinstone of cellar near Peterborough Bridge.	—	25·83	Sir J. Coode.
Newhaven	Zero of tide-gauge (Tidal Observations, 1878)	—	8·03	F. D. Banister.
Newport	Outer sill of Alexandra Dock (44 ft. below coping).	—	—	J. Abernethy.
Piel	Zero of tide-gauge	—	14·0	F. C. Stileman.
Portishead	Outer sill of Portishead Docks.	—	11·86	F. C. Stileman.
Portland	Admiralty datum (L.W.S.T.)	—	1·57	J. O. Andrews.
Portsmouth	Sill of No. 6 Dock of H.M. Dockyard (L.W.O.S.T.)	—	6·66	H. Wood.
Ramsgate	Zero of tide-gauge	—	11·72	R. Braine.
Runcorn	Sill of Duke's Dock.	—	3·46	J. F. Bateman.
Sheerness	Zero of tide-gauge (mean water level).	1·44	—	Col. Lloyd and Ordnance Survey.
Silloth	Sill of dock entrance	—	—	J. Abernethy.
Shoreham	Zero of tide-gauge (tidal observations, 1878).	—	7·75	W. Swales.
Southampton	Top of coping at N.W. corner of outer dock.	12·5	—	A. Giles.
Sutton Bridge	Zero of gauge at (94·18 ft. above, 100 ft. below Ordnance).	—	5·82	W. H. Wheeler.
Swansea	Sill of lock, East Docks	—	14·46	J. Abernethy.
Tees	177·7 ft. below top of stone sill of Fardenside House, High Worsall.	—	83·5	J. Fowler.
Tyne, river	H.W. of a spring tide (observed by George Rennie, May 31, 1813), marked on the Low Lighthouse, N. Shields.	8·94	—	P. J. Messent.
Wear	(Rennie's standard) H.W.O.S.T.	7·60	—	H. H. Wake.
Welland	Zero of gauge at Fosdyke Bridge is set to Ordnance datum.	0·0	—	W. H. Wheeler.
Whitehaven	Zero of tide-gauge	—	4·75	J. Brunlees.
Widnes	Sill of Old Dock	1·83	—	J. F. Bateman.
Wisbeach	Town datum 50 ft. below B.M. cut in church tower (being 6·375 ft. lower than Nene Valley datum).	—	32·21	W. H. Wheeler.
Yarmouth	L.W.O.S.T (tidal observations, 1878)	—	3·89	W. Teasdel.
SCOTLAND.				
Aberdeen	(Harbour Works) sill of south, or single entrance of the Victoria Dock.	—	14·62	W. Dyce Cay.
Dundee	Sill of King William IV. Dock (L.W.O.S.T.)	—	7·18	D. Cunningham.
Glasgow	Clyde datum, 6½ in. above the springing of the arches of Glasgow Bridge.	13·81	—	J. Deas.
Leith	Sill of Old Dock	—	9·03	G. Robertson.

LIST OF VARIOUS LOCAL DATUM MARKS, &c.—*continued.*

IRELAND.				
Ordnance Datum of Ireland	L.W. of Spring Tides in Dublin Bay, being 20·90 below a mark on the base course under the south window of Poolbeg Lighthouse. Supposing mean sea level on English Coast to be the same, the above datum is 8·094 ft. below mean level of sea round Ireland, which is 0·623 ft. above Ordnance datum of Great Britain. The Irish Ordnance datum is, therefore, 7·46 ft. below that of Great Britain	Ordnance Datum of Ireland		Authority
		Feet		
		Above	Below	
Belfast . .	Harbour datum, level of No. 2 Old Graving Dock sill.	2·92	—	T. R. Salmon.
Dublin . .	Port of Dublin, north wall, standard	1·43	—	B. B. Stoney.
Hawlbowline Island, near Queenstown	Floor of New Graving Dock . .	—	22·30	C. Andrews.

EUROPE.				
French Datum (Dépôt de la Guerre)	Zéro du Nivellement (Bourdaloue). This is mean tide level at Marseilles, and it is found to be 0·80m. below the mean tide level of the Atlantic and English Channel Ports of France On the assumption that this last mean sea level coincides with the mean sea level of the Ordnance of Great Britain, the French Zéro du Nivellement is 0·61m. (2·00 ft.) below the Datum of the Ordnance of Great Britain	French Zéro du Nivellement, Bourdaloue		Dépôt de la Guerre, Ponts et Chaussées (Baudot)
		Mètres		
		Above	Below	
FRANCE—				
Boulogne .	Zéro des Cartes Marines (Chazallon)	—	4·13	Ponts et Chaussées (France)
Calais . .	,, ,, ,, .	—	3·17	,,
Dieppe . .	,, ,, ,, .	—	4·21	,,
Dunkerque .	,, ,, ,, .	—	2·42	,,
Havre . .	,, ,, ,, . (Zero of self-registering tide-gauge 0·10m lower).	—	4·29	,,
Tréport . .	Zéro des Cartes Marines (Chazallon)	—	4·21	
BELGIUM .	Zéro du dépôt de la Guerre . .	—	1·37	Ponts et Chaussées (Belgium)
Ostende . .	Zéro du busc de l'écluse des bassins de Commerce (zero of self-registering gauge).	—	3·01	(Maus)
HOLLAND .	Piel d'Amsterdam (Standard level)	0·91	—	Dutch Waterstaat (Maus)



Datum for International Tidal Observations

Illustrating the 3rd Report of the Committee on the Ordnance Survey of Great Britain.

Stottiswoode & Co Lith London

Second Report of the Committee, consisting of Dr. A. W. Williamson, Professor Sir William Thomson, Mr. Bramwell (*Secretary*), Mr. St. John Vincent Day, Dr. C. W. Siemens, Mr. C. W. Merrifield, Dr. Neilson Hancock, Professor Abel, Mr. J. R. Napier, Captain Douglas Galton, Mr. Newmarch, Mr. E. H. Carbutt, Mr. Macrory, *and* Mr. H. Trueman Wood, *appointed for the purpose of watching and reporting to the Council on Patent Legislation.*

The Committee have to report that they have held several meetings, at which they prepared a memorial upon the Bill for the Amendment of the Patent Laws, brought in by the Home Secretary and the Attorney-General.

This memorial is printed as an appendix to the Report of the Council, p. lxiii.

The memorial was presented to the Attorney-General by a deputation from the Council of the Association on the 17th of May last.

The bill became a lapsed order; but the Committee have every reason to hope that their recommendations will be duly considered if a similar measure should be introduced in the next or any future session.

On Self-acting Intermittent Siphons and the Conditions which Determine the Commencement of their Action. By Rogers Field, *B.A., M. Inst. C.E.*

[A communication ordered by the General Committee to be printed *in extenso* among the Reports.]

In the discussion on Mr. Barlow's paper on the upward jets of Niagara, read at the Plymouth meeting of the Association, I made a few remarks with reference to an improved form of self-acting siphon I had invented, the action of which depends on the power of falling water to drag air along with it, and I now, by request, will give a description of the action of this siphon illustrated by a working model.

Before proceeding to describe the peculiarities of this siphon, it will be well to say a few words generally as to self-acting siphons employed for the intermittent discharge of fluids from vessels. The idea of employing siphons in this way is by no means new, and I may instance the philosophical toy, called 'Tantalus's cup,' which many of us have seen in our youth. In this cup there is a concealed siphon, which is brought into action when the cup is raised to the mouth to drink, so that the water sinks away from the lips and cannot be drunk. A self-acting siphon has also been employed for emptying vessels used for measuring water, as in Osler's and Bickley's self-recording rain gauges, as well as on a large scale for reservoirs.

The chief difficulty to be overcome in applying siphons in this way is to start them or put them in action. In an ordinary siphon, such as that shown in fig. 1, the siphon will not be put in action unless the

FIG. 1.

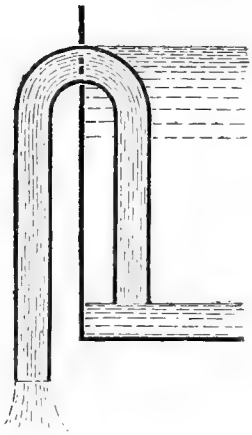


FIG. 2.

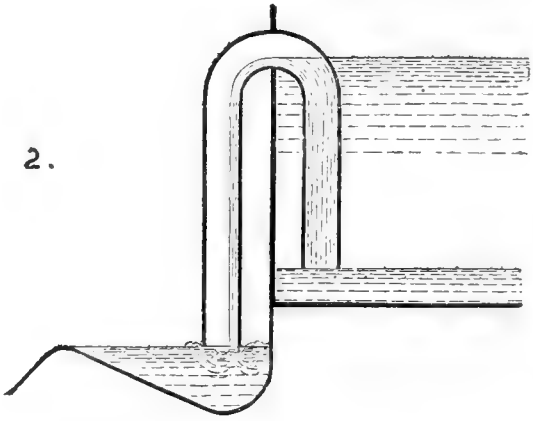
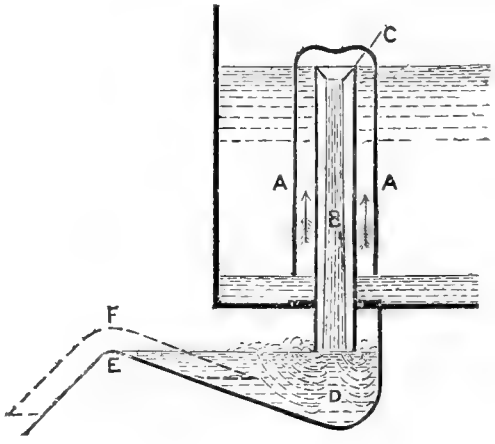


FIG. 3.



water in the vessel rises above the top of the bend of the siphon, and it will be readily seen that if the siphon is of any size, this will require a large accession of water in the tank, so that the siphon will not work except in cases where there is a large flow of water.

This difficulty can, to a considerable extent, be overcome by dipping the outer leg of the siphon in water, as shown in fig. 2. The water which runs over the bend of the siphon will then drag a certain quantity of air with it, and drive this air out at the lower mouth of the siphon, and as the air cannot return in consequence of this mouth being sealed, the air in the outer leg is gradually reduced in tension below the atmospheric pressure. Whether this partial exhaustion of the air in the outer leg is sufficient to start the siphon, depends on the quantity of water that runs over the siphon, but the quantity required will be much less than if the outer end were open, and it will not be necessary for the water in the vessel to rise above the top of the bend of the siphon.

Although the expedient of dipping the outer leg of the siphon in water greatly reduces the quantity necessary to start the siphon, the required quantity is still very considerable if the siphon is of any size, and further expedients have therefore been adopted to reduce this quantity. One of the simplest of these expedients is to have two siphons of different sizes connected together by a tube at the crown, and so arranged that the water runs through the smaller siphon first. The outer ends of both siphons are dipped in water, the smaller siphon then starts with a comparatively small quantity, and afterwards by means of the connecting tube exhausts the air from the larger siphon, and brings it also into action. This method was adopted by Professor James Thomson, F.R.S., in 1860, for his jet pump, and it was also carried out on a large scale in France in 1867, at the Reservoir de Mettersheim. In this latter case, there are two siphons of about 28 inches in diameter, each of which is put in action by a smaller siphon of 6 inches in diameter.

This expedient, however, and several others which have been adopted, leave much to be desired, as they are to a certain extent complicated, and yet do not sufficiently reduce the quantity required for starting the siphon to enable it to be used in many cases. The method which I am now about to describe is both simpler and much more effective.

In an extensive series of experiments which I tried some years ago on siphons, with their outer legs dipped in water, I was much puzzled by finding that the quantity of water necessary to put a siphon of given size in action varied in the most unaccountable way at different times. The only difference that could be perceived between the cases in which the siphon started and those in which it did not start was, that in the former case air-bubbles escaped freely at the mouth of the siphon, whereas in the latter case, under apparently the same conditions, very few bubbles came out. At last the idea suggested itself to me of making a portion of the siphon in glass, so as to see what was going on inside the pipe, when the cause of the irregularity was at once discovered. Sometimes the water which ran over the bend adhered closely to the sides of the pipe; at other times a portion of it would fall more or less clear of the sides. When the water adhered to the sides it produced very little effect in displacing the air, so that only a small quantity of air was driven through the water at the mouth of the siphon. When, on the other hand, the water fell clear of the sides, it produced a great effect in displacing the air, and large bubbles of air at once escaped from the mouth of the siphon.

I pursued the investigation further by producing artificial irregularities in the pipe, and I then found the more completely I could throw the water clear of the sides of the pipe, the greater effect it produced in expelling the air and starting the siphon. The form of siphon which I have finally adopted as most effective is shown in fig. 3, and in the working model.

The siphon consists of two concentric tubes, A and B, the outer one, A, being closed at the top, and steadied and supported by three radial ribs projecting from the inner tube, B. The annular space between A and B constitutes the ascending or shorter leg of the siphon, and the inner tube, B, the descending or longer leg. At the upper mouth of B is fixed a conical shell, C, projecting inwards clear from the inner surface of the tube, B. The lower mouth of B dips into a discharging trough, D, which has a weir, E, level with this lower mouth. The action is as follows:—When the vessel is full, the water begins to trickle over the edge of the conical shell, C, and is so directed by the shell as to fall towards the centre of the tube, B, quite clear of the sides, thus producing the maximum effect in displacing the air. The action of the siphon soon commences, and continues till the water in the tank is lowered to the level of the lower mouth of A, after which air is admitted by that mouth to the siphon, and the action ceases.

In some cases, the quantity of air admitted at the end of the discharge, though sufficient to stop the siphon, is not sufficient to fully charge it with air, so that the next discharge will commence before the water in the vessel has risen to its full height. To obviate this, the best expedient is a secondary siphon, F, fixed in the trough, D, and put into action by the discharge from the larger siphon, A B. When this discharge has stopped, the siphon F continues in operation, so that the water in the trough, D, is drawn off, the lower mouth of the pipe, B, unsealed, and the larger siphon fully charged with air. Presently, also, the action of the secondary siphon, F, is also stopped by the admission of air. When the vessel is filled, and water trickles over the shell, C, the trough D is again filled up to the level of the weir, and the siphon A B becomes sealed.

There are other minor conditions which affect the commencement of the automatic action of the siphon, such as the roughness of the top of the conical shell C, the ratio of the area of the tank to the area of the siphon, the length of the siphon, &c., but these I will not go into.

In conclusion, it is evident that the above form of self-acting siphon will be of great practical use for a number of purposes. I will merely mention one, namely, that of flushing sewers, by means of small quantities of water which ordinarily run to waste. Take, for instance, a drinking fountain, the water which escapes from it is, under ordinary circumstances, absolutely useless for flushing purposes. Collect this water, however, in a tank with a large self-acting siphon, and as soon as the tank is full, be it in one day or in several days, the siphon will be brought into action, and the contents of the tank discharged with great rapidity. The trickle from a drinking fountain would start a siphon of as much as 10 or 12 inches' diameter of the improved form, and would, therefore, flush a sewer of considerable size, say nearly 3 feet in diameter.

On some further Evidence as to the Range of the Palæozoic Rocks beneath the South-East of England. By Robert A. C. Godwin-Austen, *F.R.S., F.G.S.*

[A communication ordered by the General Committee to be printed *in extenso* among the Reports.]

[Plate XIV.]

In a communication to the Geological Section of the meeting of the British Association at Plymouth in 1878 I called attention to the significance of the result of the deep boring at Messrs. Meux's, as to the Upper Devonian beds there met with, next beneath the cretaceous strata, also as to the importance of some further knowledge as to the direction of the dip of the said Upper Devonian beds. An accurate acquaintance with this point is essentially needed with reference to its immediate bearing on a question which may possibly become one of national importance, namely, the place of the true Coal-measure series, beneath our south-east area, and which must serve as an excuse for another short communication on the same subject.

The question involved has attracted the attention of sundry foreign geologists during the past year; and upon our own area facts have been ascertained which now enable us to arrive inferentially at what, but a year since, was mere speculation.

M. Dewalque, at a meeting of the Belgian Geological Society,[1] remarked first on the absence of Jurassic and Triassic deposits, as along the Palæozoic ridge extending from the Ardennes by the north of France; being just what the borings at St. Trond, Laeken, Menin, and Ostende, would indicate. Secondly, that inasmuch as the Belgian and north of France primary formations are extended into England, it is an important point, with reference to the prolongation of the Belgian coal-basin, that London should be known to be situated immediately above a formation which is itself so close to the Coal-measures. 'The supposition that the dip of these Upper Devonian beds' is to the south, and that they belong to the extension of our northern basin, is that which is the most probable. The coal formation may therefore occur at a short distance (quelques kilomètres) south of London, and at a workable depth.'

With a southern dip it may be that these beds (Upper Devonian) belong to the extension of our southern basin. In this case coal may occur in the north as well as on the south, and nearer on this side (N.) than on the south. Should there be such a coal basin, it might be as useless as ours (Belgian) of the 'Condros and the Entre Sambre and Meuse.'[2]

In answer to some observations of M. J. Van Scherpenzeel Thim,

[1] Société Géologique de Belgiques, Bulletin LXV.

[2] The exact significance of this latter alternative of the Belgian geologist may not perhaps be understood by English geologists generally, as it has reference to a feature in the physical structure of Belgium, but the which is very properly referred to by M. Dewalque now that the Palæozoic band of the Continent is known to reach our south-east district. The band of Belgian and North of France coal-measures may be truly represented as trough-shaped, however produced.

The northern border of the coal basin of Namur is formed of strata each older than the other in a northerly direction. The carboniferous series occurs at the surface at Soignies and Journay; the Devonian at Rhines; the Silurian at Gembloux. To the north the Silurian strata sink—at Bruxelles they are at 200, and at 300 at Ostende. The primary formation of the North of Belgium undulates, and the like may be supposed to be the arrangement here.

M. Dewalque added: 'Starting from the supposition that our (Belgian) old strata are prolonged westward into England, and from the fact that Upper Devonian strata occur under London, we are led to admit that the band of Silurian slates of the Ostende boring must pass north of London. These slates, which are referable to those of Tubise, must be separated from Upper Devonian by other beds, such as the black slates of the Menin shaft, which are Silurian. Considering the geographical position of these three places, together with the east and west direction of our older formations, it would not seem that their prolongation into England would carry them sufficiently north of London, so that the Devonian beds there should represent our Condros basin, and not that of Namur.

'If then at that place (London) we are in a prolongation of the Namur basin, the strata at Meux's must dip south; consequently, it is most probable that the Coal-measures are to be found at a short distance south.'

Such were the inferences drawn by M. Dewalque in 1878 from the result of boring at Messrs. Meux's.

It may be stated that at the several places named, the Palæozoic strata reached were, at Ostende, Silurian; at Menin, Silurian, like the strata at Gambloux; at Laeken, also Silurian.

The supposition that the Silurian strata met with at Ostende would, in their course westward, pass north of London has been proved by the occurrence of beds of Wenlock age at Ware, near Hertford, twenty miles north of London. This discovery has come most opportunely to supply the information which, only a year since, was needed as to the dip of the Upper Devonian strata at Messrs. Meux's.

The succession of the Palæozoic strata, on this the English side of the Channel, even into the far west, is just what it is in Belgium and the north of France. From Brussels and Ostende, from north to south, the successive members of the series mostly rise to the surface, and are exposed in all the valleys of denudation extending north from the line of the Coal-measures, as long since laid down by Dumont.

With this guidance, and in spite of little as yet known with respect to our own underground structure on the south-east, it can be safely put in relation with what obtains on the European continent for an extent of 400 miles. The order in which the successive members of the Palæozoic series rise to the surface from beneath one another there, may be taken as our guide as to the order and relation of the Upper Devonian at the end of Tottenham Court Road and Oxford Street, and the section at Ware.

The question of the strike and direction of the dip of the beds at Meux's is now determined as forming part of the northern base of the trough, containing first the mountain limestone series, and next, above, the true Coal-measures.

For practical guidance one point alone remains to be considered: from the place of the Upper Devonian strata in the heart of London, what must be allowed for the breadth of the outcrop of the mountain limestone series, next in sequence?

In parts of Belgium the mountain limestone has been estimated as 600 feet thick; it is less than that in easterly and westerly directions.

The nearest place to London at which this is exposed is on the north of the Boulonnais denudation, where, with its associated beds, it may be put at 600 feet. The breadth of such a mass at its outcrop, and with an angle of 30 to 35 degrees, such as the Devonian beds at Meux's had, would

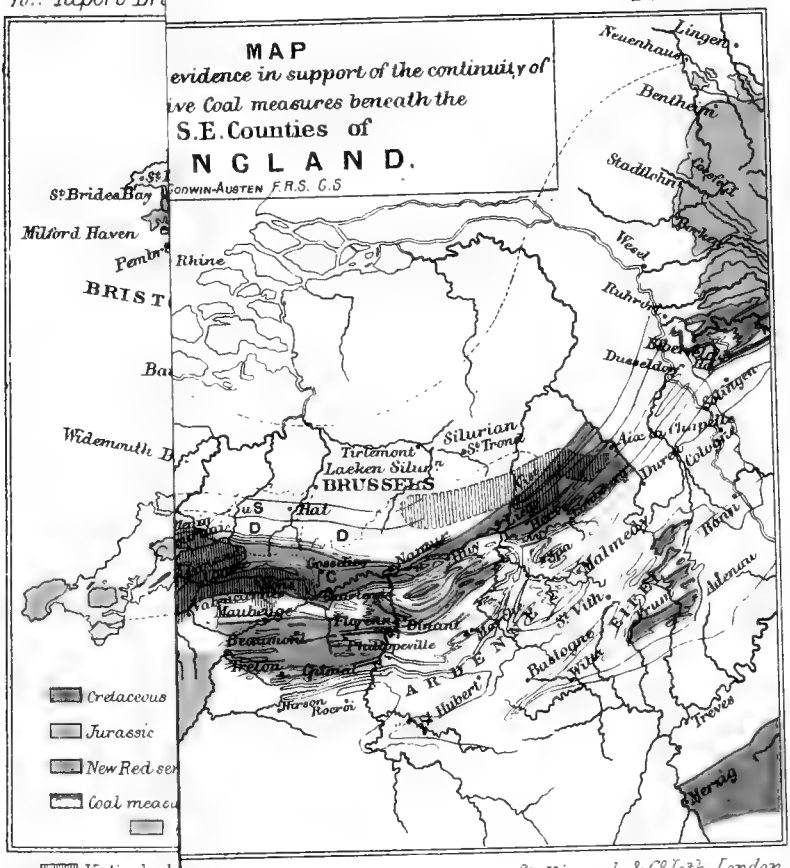

MAP
evidence in support of the continuity of
ive Coal measures beneath the
S.E. Counties of
NGLAND.
GODWIN-AUSTEN F.R.S. G.S
St Brides Bay
Milford Haven
Rhine
BRIST
Widemouth
Neuenhaus
Lingen
Benthem
Stadtlohn
Weed
Ruhrort
Elberfeld
Düsseldorf
Aix la Chapelle
Liège
Tirlemont
Laeken Silur.n
BRUSSELS
Silurian
St Trond
Flat
Namur
Hun
Malmedy
Bonn
Maubeuge
Beaumont
Florennes
Dinant
Philippeville
Bastogne
Wilts
Ardennes
Trèves
Metz
Cretaceous
Jurassic
New Red ser
Coal meas
Vertical sh
Hall & Pitts Lith London.
Edinburgh & Co.
Bottiswoode & Co. Lith. London.

Plate XIV

MAP
To illustrate the evidence in support of the continuity of productive coal measures beneath the
S.E. Counties of
ENGLAND
AXIS
PALAEOZOICS
ENGLISH CHANNEL
BRITTANY

be nearly doubled, or about 1200 feet; in other words, the lower members of the true Coal-measure formation may be fairly expected to occur at about that distance south from the corner of Tottenham Court Road and Oxford Street, the upper, or productive Coal measure, still farther to the south.

What has been ascertained beyond all doubt as to the line of section underlying a part of our English area from London to Ware, may be safely taken as holding good for a great extent of country on the east as on the west. The ages of more modern overlying formations do not affect this question, as is shown by the borings here in England, but more abundantly on the European continent. In our attempts to trace accurately hidden physical arrangements of the earth's crust, the restrictions to be observed are the positive data of the ascertained thicknesses of the several formations, and their positions, and which enable us to replace, without much chance of error, the line of each band and of its direction of dip.

Hydrography, Past and Present.

By Lieutenant G. T. Temple, *R.N.*, *F.R.G.S.*

[A communication ordered by the General Committee to be printed *in extenso* among the Reports.]

[Plate XV.]

The immediate aim of this paper is to bring to the notice of the section the present state of hydrographical science, which forms an essential part of the machinery by which our enormous commerce is carried on in time of peace, and defended during war. The subject is therefore of great national importance, and I sincerely trust that it will meet with your favourable consideration.

In the annual address to the Royal Geographical Society, the unsatisfactory state of the Admiralty charts for South Africa was pointed out by our President, Mr. Clements Markham, whose unremitting devotion to the advancement of geographical science is well known to most of those present. He observed that the war in Zulu-Land had called public attention to the unsurveyed state of parts of the coast of South Africa, H.M. Ships *Active* and *Tenedos* having been placed in great danger through grounding on some unknown reefs between the Tugela River and Point Durnford. He told us also that both the east and west coasts of South Africa (northwards from Bashee River on one side, and St. Helena Bay on the other) have not been sounded since the days of Captain Owen, half a century ago. This must have been a startling announcement to those who fancy that we already know the world perfectly, and who are not aware that the outlines given on the beautiful maps of Keith Johnston and others are, to a great extent, mere guesswork. It was, however, well known to the few who for some years past have been steadfastly working to restore the surveying branch of the Navy to the high position it formerly held.

The story of this essential branch of the public service, which has been characterised as 'not only useful in peace, but terrible in war,' is a curious illustration of the difficulties attending the construction and

maintenance of any thoroughly good institution. 'Inch by inch,' we are told, did the surveying service 'fight its way into life,' until under the bold and skilful rule of Sir Francis Beaufort, it achieved the success prepared for it by the struggles and death of Dalrymple, and the earnest efforts of Hurd, Michael Walker, and Parry.

Although many unsurveyed coasts were charted during the last century by Cook, Vancouver, Flinders, and others, yet it was not until 1795 that the Hydrographical Department of the Admiralty was established by Order in Council. It consisted of the hydrographer (Mr. Dalrymple), one assistant, and a draughtsman. Mr. Dalrymple's orders were 'to take charge and custody of such plans and charts as then were, or should thereafter, be deposited at the Admiralty, and to select and compile such information as might appear to be requisite for the purpose of improving navigation.' From this small beginning, the important department that may now be fairly regarded as the main source of hydrographical information to the civilised world was developed. It is impossible, in the limited time at my disposal, to trace the progress of the department step by step; it is also unnecessary, as full information on the subject may be found in the *Geographical Magazines* for April and July, 1874, and in the *United Service Gazettes* for the 12th and 26th of July, and the 16th of August, 1879. It will be sufficient to say that after many struggles and reverses it advanced slowly but surely, until the year 1849 found no less than twelve surveying ships in commission, under the late eminent hydrographer Sir Francis Beaufort, while twenty-three officers were borne on ships' books for detached surveying service. After presiding over the Hydrographical Department for nearly a quarter of a century, Sir Francis retired in 1854, leaving a surveying force of nineteen captains and ten commanders, with sixteen lieutenants in training, and eight ships in commission, notwithstanding the fact that we were then at war with Russia, and that three surveying captains and two commanders were employed in Arctic service. The views of a nation are supposed to extend with its opulence and prosperity, but in the middle of 1873, the surveying service had fallen so low that only one of Her Majesty's ships (the *Shearwater*, under Commander Wharton) was engaged in actual surveying duties. It is true that the *Challenger* was also in commission under Sir George Nares, but she was an exploring rather than a surveying vessel. Since then matters have somewhat improved, but we still find a decrease of ships and men where there should have been increase.

In January 1873 the sad falling-off in the surveying service was noticed in the press, a leader in the *Daily News* showing that, although the annual naval expenditure had increased from about four and a half to seven and a half millions, and the tonnage of the mercantile navy from less than four and a half to upwards of seven million tons, yet the surveying service had been allowed to decline. In December of the same year, Sir Bartle Frere wrote to Mr. Gladstone, earnestly protesting against the insinuation that voyages of survey and discovery were not 'strictly professional naval services;' at the same time expressing his belief that there are few better naval schools than a surveying or discovery ship, and that if such ships were multiplied, not only would commerce benefit, but men-of-war would be better supplied with practical seamen than is possible at present. In April 1874, Mr. Markham pointed out, in the *Geographical Magazine*, the great need that our rulers should more fully appreciate the importance of an efficient administration of the

surveying service; and expressed an earnest hope that the days of false economy and lamentable neglect of enterprises of discovery and survey were numbered. In the following July he showed that although one of the most obvious duties of a country with an extensive seaboard and a great sea-borne trade is to provide for the safety of vessels frequenting her ports, by the provision of lighthouses and buoys, and, above all, by the preparation of reliable charts and sailing directions, yet nothing had been done for a space of twelve years for the coasts of our Indian Empire. In February 1875, Captain Hull read an able paper at the Royal United Service Institution, in which he especially drew attention to the unsurveyed parts of the world. The *Army and Navy Gazette* has also taken the matter up, and on the 22nd of last March published a letter from 'An Old Officer,' headed 'The One Man Needful.' This letter pointed out that when a competent successor to the late Admiral Bedford was required at the Board of Trade, it appeared that such a man was not to be found in England. The only man said to be fit was Sir George Nares, who was then in command of the *Alert* surveying the Straits of Magellan. Sir George, who is apparently a sort of hydrographic Sir Garnet Wolseley, was accordingly taken out of the *Alert*, just as in 1874 he was taken out of the *Challenger* to command the Arctic Expedition, in both cases leaving his work to be carried on by his executors, or the men he left behind him. The reason for this is obvious; in place of the *nine and twenty* captains and commanders, from whom, in 1854, competent men might have been selected either to command Arctic expeditions, to fill the place of Admiral Bedford at the Board of Trade, or that of Sir George Nares in the Straits of Magellan, we have now *only two*. One great evil arising from the want of trained men of the required rank is that the surveying service continually suffers demoralisation from the appointment of inexperienced chiefs, who are obliged to learn their duties from their juniors, a proceeding curiously at variance with the general tone of this age of competition.

At the present time the Hydrographical Department of the Admiralty consists of twenty-four individuals, including the hydrographer and four messengers and packers. The expenses of the department are provided for under Vote V, which includes several other branches of the scientific service. The total grant for the scientific branch was 120,357*l.* in 1861–62, and 106,041*l.* in 1878–79, a deplorable reduction of more than 14,000*l.*, which represents a proportionate decrease in the amount of useful work done. And yet, as I shall presently show, the Hydrographic Office is in a great measure self-supporting, and might be made still more so by the ordinary mercantile expedient of increasing the size of an establishment to meet the requirements of customers.

It is beyond the scope of this paper to enter fully into the manifold duties of the department, but amongst the most important are the following:—To execute accurate surveys of all parts of the world that are visited by British ships; to prepare and publish these surveys in the form of charts; to write and publish sailing directions to accompany the charts; to collect, compile, and promptly publish all hydrographic information; and to keep the charts and other nautical documents corrected up to the latest dates. It is also the duty of the department not only to supply Her Majesty's ships, but also to see that there are always sufficient charts and nautical works to meet the public demand. It will give some idea of the extent of this demand to state that on an average upwards of

106,000 copies of Admiralty charts, and nearly 19,000 copies of the *Nautical Almanac*, besides sailing directions and other books, are sold annually to the general public and to foreign governments, exclusive of the supply to the Royal Navy. Four hundred and fifty chart boxes, each containing from 300 to 400 charts, are required for the Navy, and 1000 chronometers are in constant circulation between the Royal Observatory and Her Majesty's ships. Foreign navies navigate by our charts, and all our sailing directions are immediately translated, especially by the French authorities. Another important function of the department is its responsibility for all matters connected with the compasses of Her Majesty's ships.

The preparation of charts is under a superintendent, whose duties are of a very important and responsible character. They are ably performed by Commander Thomas A. Hull, who received his early education in the school of Sir Francis Beaufort, and whose abilities as sailor, surveyor, and draughtsman are well known. I have here a few Admiralty charts selected to give a general idea of the different styles. They may be divided into five classes: ocean charts, general charts of any particular country or coast, coast charts, plans of harbours, and physical charts. The latter have given a greater impetus to our knowledge of the causes and effects of winds, currents, and temperatures than any publications that have preceded them, and they have already been reproduced in France and other countries. In the course of a voyage the sailor uses four classes of charts. Fixing his position by astronomical observations, he marks the ship's place and her track from day to day upon the ocean chart, which is drawn on a very small scale. The curved lines on these charts represent the lines of equal magnetic variation, and the small figures show the deep-sea soundings; these are of the greatest value to our merchants, and to those interested in the laying of submarine cables. They are also the result of great care and experience, as the ship must be kept for hours in the same position to obtain them, telegraph engineers requiring not only accurate position and depth of water, but also samples of the bottom at great depths. They want to know what kind of bed their cables are to lie upon. As the land is neared, larger scales are required, and the next chart used is the general chart of the country the vessel is bound to. When in sight of land, a coast sheet is prepared; and last of all comes the plan of the haven in which the weather-beaten ship is to rest.

When a coast has only been partially surveyed, the charts for it are drawn in a light and unfinished style, which is a sufficient warning to the initiated that the land must be approached with caution. As the great aim of the Hydrographic Department is correctness, all charts are subjected to the searching criticism of the naval assistants before publication, and it is to this measure that their extreme accuracy is to a great extent due. The charts are not by any means done with when issued; they have then to be kept up to date. In fact, every chart published may be regarded as a sort of official child, requiring the paternal vigilance of the office to insure its doing good instead of evil. Correcting the charts is a very delicate and responsible duty. All changes of lights, buoys, and beacons have to be inserted, and as there are in round numbers 4000 lights and 10,000 buoys to be watched over, it is no trifling task. The change of a single light or buoy sometimes necessitates the correction of no less than five charts. These corrections, though small, must be made

with the greatest care, for if such *important simplicities* are neglected, and the chart be incorrect in these essentials, no finish or cunning engraving can save its credit; it is beauty without discretion, a danger instead of a safeguard. A very slight error in the position, colour, or character, of a light or buoy, or in the insertion of a simple dot, cross, or figure, may lead to the gravest disasters. Charts, like books, require study to be properly understood, and familiarity with the abbreviations and conventional signs is essential. A good chart, to those who study it with the attention it deserves, is 'a thing of beauty and a joy for ever.' My life has been saved more than once by Admiralty charts, and therefore I speak of them with affection. From six to twelve copies of each chart are kept in the office for correction, and as there are about 2700 charts in circulation, the number collected at one time on the shelves may exceed 30,000. The assertion of the *Daily News* that 'space is wanted to spread out a chart, without having first to remove books or papers that are at the same time under consideration,' is literally true. At the Dépôt des Cartes et Plans de la Marine, in Paris, a greater amount of space is allotted to the British charts alone than the English Admiralty affords for those of the whole world. From the sale of charts the Treasury receives about 6000*l.* a year; but though the number of charts increases yearly, though the work required is more finished and elaborate, and though the demand and sale have also increased, there is no corresponding addition to the staff employed. The Hydrographer's Report for 1878–79 tells us that during the year sixty-one new charts and plans were published, 1950 charts were corrected, and 202,800 charts were printed for Her Majesty's service and for the use of the general public. Although the maximum of work which this branch of the office manages to perform with a minimum of hands is truly surprising, yet the present staff, which consists of a chief draughtsman and five assistants, is unequal to the demands upon it, and the unpublished information is steadily accumulating. The result is that insurance is high, and that valuable cargoes, and still more valuable lives, are thrown away in order that the already narrow limits of the scientific vote may be still further contracted. It is true that this vote has been reduced by a few thousands; but how much did it cost to repair the *Lord Clyde* and the *Agincourt*, and how many vessels are annually lost on partially surveyed or little-known coasts?

Having now sketched the constitution and working of the Hydrographical Department, I shall endeavour to show what it is now doing, and what remains to be done. On the outline chart of the world which accompanies this paper, an attempt has been made to depict, faithfully, the present state of hydrography, and I fear it will be only too easy to show that a surveying Alexander need not weep. The surveyed coasts are marked by a *heavy coast line*; those only partially surveyed, by *shading*; while coasts that have merely been explored are drawn in *fine outline*. The ships show the stations of the four regular surveying vessels and three schooners at present in commission; and the crosses show the head-quarters of officers doing their best with small craft, or with hired boats and crews, the latter method being adopted, where practicable, with a view to economy. In some cases the expenses are shared by Colonial Governments.

Owing to the vastness of the subject, I fear that errors will be detected in the chart by sailors knowing the respective coasts; I shall be

only too glad to find that the heavy coast line should be extended, but I trust that no one will be able to remove any of that line or the shading.

The large cross in the Bay of Bengal represents the Department recently established in India for Marine Surveys, and which will be mentioned hereafter.

On the home coast there is one small surveying vessel, the *Porcupine*, under Staff-Captain Parsons, as well as the hired steamer, *Knight Errant*, under Staff-Commander Stanley. It should be borne in mind that owing to their shifting nature the sands surrounding our shores require constant examination, while the mouths of rivers are often as changeable as the fashions. The continuous attention of a strong surveying staff is therefore indispensable, if the charts of our own coasts are to be kept in good working order. It is not enough to make a road and then leave it, or to lay down rails and then neglect the permanent way. The same principle applies to our ocean highways, and charts, like roads, require constant attention and repair to prevent them from falling into decay.

The *Alert* left England in September last under the command of Sir George Nares, and reached the scene of her first year's labours—Magellan Strait and the adjacent waters—early in January. Sir George, as already observed, has since accepted an appointment at the Board of Trade.

The *Fawn*, under Commander Wharton, after determining the position of the Cosmoledo group, and other islands to the north-west of Madagascar, has been transferred, at the request of Admiral Sir Geoffrey Hornby, to the unsurveyed waters of the Sea of Marmora.

The *Magpie* has been employed on the sea-board of China, between Hong-Kong and Shanghai, and is now in the Gulf of Tong-King, while the *Sylvia*, under Commander Pelham Aldrich, is steadily working on the western shores of Japan.

It is much to be regretted that a very important part of the complement of officers in these vessels is generally overlooked. The well-known labours of Sir Wyville Thomson and his staff lead us to hope that the surveying ships of the future will carry a skilled naturalist, as in the days of Sir Francis Beaufort. The opportunities offered by a surveying vessel for observing and collecting on distant and little-known coasts, such as those of East Africa and Japan, are so exceptional that we can only wonder at their being neglected. In other respects, also, an amount of economy is now enforced which impairs efficiency.

Staff-Commander Maxwell, in the hired steamer *Gulnare*, is working in Newfoundland, and the shores of Jamaica are being surveyed by Lieutenant Pullen, in the schooner *Sparrowhawk*.

Lieutenant Moore, in the *Alacrity* schooner, is following up the examination of the Fiji Islands; and Lieutenant Richards, in the schooner *Renard*, is under the orders of the commodore of the Australian station. The Hydrographer observes that the useful surveying work performed among dangerous reefs, in these two small sailing vessels, deserves warm commendation.

The Queensland coast survey, under Staff-Commander Bedwell, is now being pressed forward in a hired steamer. Staff-Commander Howard is working on the mainland in the neighbourhood of Nuyts Archipelago and Fowler Bay; and we are also told by the Hydrographer that Staff-Commander Archdeacon, with one naval assistant, has been working hard for six years in Western Australia, with '*limited nautical resources*.' Now this phrase is worthy of special notice. It means that

the surveyors cannot always get small craft wherein to obtain soundings, and however truly a coast may be delineated, the charts are almost useless unless the soundings are correct. In fact, soundings, which represent the depth and bottom of the sea, constitute the great point of difference between a chart and a map, and it is upon their accuracy that the character of the nautical surveyor mainly depends. The land work may be done by the soldier or civil engineer, but the sounding is the sailor's portion, requiring all the ready wit and tact of his profession. Well-sounded localities may be safely navigated by means of the lead, a simple but very important instrument, which is only too frequently neglected. In thick weather the lead and line are to the sailor as antennæ to a beetle—though blinded by 'any vile congregation of vapours,' he may still *feel* his way. Another great disadvantage of detached surveying parties is that we lose that grand school for practical nautical surveying, a ship, and the disciplined life of a man-of-war. 'No man,' says Captain Hull, in his useful treatise on surveying, 'can be expected to attain a trusted position as a nautical surveyor who is not essentially a good officer and sailor, or, to speak more exactly, a good pilot, knowing how to handle a body of men, the requirements of a ship, and the room she wants to wear, stay, or anchor in. This knowledge cannot be acquired under the 'one-man-and-a-boy' system. It is in ships only that men can discover 'the secrets of the sea,' or, to quote Longfellow,

> Only those who brave its dangers
> Comprehend its mystery.

Now Mr. Laughton observes, in his work on nautical surveying, that 'acquaintance with both the practice and theory of surveying is a necessary part of the training of every naval officer, without which he cannot have an intelligent understanding of the charts, the methods of using them, and the confidence to be placed in them.' It is also a favourite dictum of Admiral Ryder's that a *fair* surveyor must be a *good* navigator. The battle of the Nile could never have been fought at the hour it was if Nelson had not been a pilot as well as an Admiral. At Copenhagen, also, he made a rough survey of the approaches, and was thus able to take his squadron close to the batteries.

In the 'Navy List' for August we find that only fifty-three officers are now employed on surveying service, and if we exclude those working under the Indian Department the total is reduced to forty-nine, or but little more than half the number left by Sir Francis Beaufort a quarter of a century ago.

While the surveying service has thus been steadily retrograding, the energy of the British merchant and shipowner has almost annihilated distance. With your permission, therefore, we will just run round the world, noting the surveyed and unsurveyed coasts as we pass them, and I will try to make our voyage at least *one* of the shortest on record.

Although the *dark* line naturally prevails over European coasts, yet before we are out of the Bay of Biscay we come to the *shading* that necessitates caution, the shores of the Peninsula being still only partially surveyed. Madeira and the Canaries may be considered as done; the Cape de Verd Islands, however, require further examination.

Passing the West Indies, where the greater portion of San Domingo and Porto Rico require surveying, we first anchor at Bahia, a surveyed

port, with, however, some unexamined shoal ground on the western side of the entrance.

Pushing onward to Rio, we are still on the *dark* line, but on leaving that beautiful harbour we enter a partially surveyed region until we come to the River Plate, of which a survey is much required.

During the voyage to Cape Virgins we have time to pay a respectful tribute to the memory of Admiral Robert FitzRoy, who with limited means, and in a marvellously short time, mapped the coast of South America from the River Plate in the Atlantic to the Guayaquil in the Pacific. Sir Francis Beaufort reported to the House of Commons, in 1848, that 'all that is *immediately* wanted of these shores has been already achieved by the splendid survey of Captain Robert FitzRoy.' That, however, was before the days of steamships 375 feet long, and before the Strait of Magellan was the high road to the Pacific Ocean.

Entering the Strait of Magellan, our charts carry us safely on for 110 miles, when we again come to partially surveyed ground.

We should like to continue our voyage by the inner channels leading northward from Magellan, but as there are orders from the owners against using these partially surveyed waters, we are reluctantly forced into the Pacific (an ocean by no means worthy of its name in the vicinity of Cape Pillar) with a loss of fuel and comfort, and much wear and tear of ship and engines. The rapidly increasing traffic of large and powerful steamers between Europe and the western coasts of America, points to the urgent necessity for a thorough survey of Magellan Strait, and the channels leading northward to the Gulf of Peñas.

Pursuing our way along the coast of Chili, whose increasing trade with this country would be much benefited by better charts, we touch at Valparaiso, Callao, and Payta; but we cannot place reliance on our charts until we reach the River Guayaquil. The sight of this coast reminds us how the *Independencia*, pounding along with vicious intent to ram and utterly annihilate the *Covadonga*, suddenly found herself on the reef which her clever opponent avoided, and so lost the day and herself too. It was pilotage and cool nerve, not gunnery, that enabled the little wooden ship to cause the destruction of Peru's finest and most powerful ironclad, and the moral is that though ships and guns may be brought to perfection, yet they will avail nothing without skilled pilots and trustworthy charts.

From Guayaquil to Panama we are on the *dark* line, therefore, venturing nearer to the shore, we can coast along one of the most beautiful and interesting parts of the globe, passing La Plata island, where Drake divided the spoils of the *Cacafuego*. 'In sea-divinity,' it has been quaintly said, 'the case was clear, the King of Spain's subjects had undone Mr. Drake, and therefore Mr. Drake was entitled to take the best satisfaction he could on the subjects of the King of Spain.' We also pass Gallo island, where Pizarro drew the famous line on the sand, over which (as we are told by Mr. Markham in his 'Reports on the Discovery of Peru') sixteen of his followers crossed.

Entering the Bay of Panama, we pass the beautiful Pearl Islands, which have been well described as a perfumed archipelago, lying like baskets of flowers on the tranquil surface of the ocean. To the eastward lies the Gulf of San Miguel, where Balboa, after a journey of twenty-five days across swamps, rivers, and woods, took possession of the Pacific Ocean in the name of the King of Spain and the Indies. A branch of

the cold Peruvian current renders the temperature pleasanter here than it is at a distance from the coast, but during the wet season 'it pours,' says old Dampier, 'as out of a sieve.'

Before leaving Panama, let us reflect upon the advantage to English commerce of continuing the survey, begun by Sir Henry Kellett, from Guayaquil to Cape Pillar. The trade of this part of South America has enormously increased since the introduction of steam. The enterprise of the Pacific Steam Navigation Company has diverted the trade from the Isthmus of Panama towards the Strait of Magellan, and this new stream of travel and commerce has been so successful that the Company's fleet of magnificent steamships is barely sufficient to meet the demands upon it. In 1874, 524 voyages on the coast and 124 to Europe, were made by the various steamers of six different companies.

Looking northward from Panama, there is much work to be done. The rising trade of the Central American ports calls for more attention to coasts of which we have little information since the days of Malaspina in 1794. A partial survey of the coast and Gulf of California has been made by officers of the United States Navy, who are, I believe, about to extend their operations to the southward.

In the North Pacific our chart of that important group, the Sandwich Islands, is said to be 'from various but imperfect authorities,' and something better than this is required in 1879. We may also notice that Queen Charlotte Island is only explored.

Leaving Panama, we pass the Galapagos, where nothing is immediately required, and come next to the Low Archipelago, where the three symbols are blended. Here we find that the ocean roads followed by vessels from Panama and Valparaiso, through dangerous patches of coral, are sadly in need of repair.

After touching at the beautiful and famous Tahiti, we pass through the Friendly Islands and our new colony of Fiji, rejoicing to see Lieutenant Moore hard at work with his smart little schooner, for reliable charts are much wanted here to clear away doubtful dangers.

Readers of Dickens will remember how Quilp, when despatching Sampson Brass home one night in what sailors call a pea-soup fog, conducts his guest to the door, and tells him the way lies through a lane in which there is a savage dog, who generally lives on the right-hand side, but at times conceals himself on the left ready for a spring. He cautions Brass to take great care of himself, blows out the light, slams the door, and leaves him. What a splendid hydrographic official Daniel Quilp would have made! To tell a man there is a rock in a certain passage, and not to tell him where it is, is virtually to block up that passage, and the caution is of little use except to some comfortable official, who, if anything happens, is able to look wise and say 'I told you so.'

After calling at Sydney, where we hear that the coasts of New Zealand are still unfinished, we find that the islands and dangers in the much-used routes between Australia and China are a constant source of anxiety, and it is not until we are northward of the Caroline Islands that our captain is able to go below and take off his boots, in which for some time past he has been obliged to sleep.

After visiting Hong Kong and Singapore, we pass through the Malacca Strait to the Indian Ocean, impressed with the idea that the *Magpie* and *Sylvia* have got their work cut out for them in those great seats of industry China and Japan.

Thanks to the unflagging energy of Mr. Clements Markham, we leave the Indian coasts to the able treatment of Captain Taylor and his well-organised staff; but as the Indian Marine Survey forms the subject of a separate paper in this section I shall not further allude to it.

We have no time to visit the east coast of Africa; and the state of the charts, as illustrated by the *Active* and *Tenedos*, would render it imprudent to do so under any circumstances. When reading of the important services lately rendered by Captain Campbell and his *Active* brigade, it is humiliating to reflect that they might have been lost to us, and gained by the submarine fleet, in order to save the expense of executing a much-needed survey.

The Red Sea being unfortunately *shaded*, we are unable to use the inshore passages, except in the Mussawa Channel, and consequently suffer much discomfort from the violence of the winds. The trade through the Suez Canal points to the necessity for connecting the surveys of the Strait of Bab-el-Mandeb and the Gulf of Suez.

In the Mediterranean, we notice with regret, mingled with surprise, that the coast of Karamania is only partially surveyed, and that the *shading* also extends from Alexandria to Sphax in Tunis, the *black* spot representing the harbour of Tripoli.

Being by this time hardy travellers, we decide on a trip across the North Sea before the end of the season, and therefore land at Brindisi and make the best of our way to Hull, marvelling much at the immense tracts of coast that are still unsurveyed.

I need hardly remind you that amongst other things we are indebted to Scandinavia for large quantities of timber and iron, or that the iron from the Dannemora mines supplies us with our finest steel. The people also, and especially those of Norway, are peculiarly interesting to the British nation. They have, morally and politically, a claim upon us; and among them we may trace the germ of perhaps nearly all the free institutions which distinguish the British Constitution at the present day.

We leave Hull with a fair wind, but meet with a heavy north-westerly gale off the coast of Norway; and after an anxious night, daylight finds us, partially disabled, driving rapidly towards a formidable iron-bound shore, fronted by rocks above and below water. Our case seems desperate; we cannot get out to sea, and pilots cannot get out to us; the Admiralty charts are practically useless, for they are on a very small scale, and we are now dashing before sea and wind towards a terrible line of breakers. The captain is out on the bowsprit, however, and fortunately discovers an opening just when destruction appears inevitable. We escape the outer rocks, by a miracle as it seems, and at last a pilot boat sheers cautiously alongside. A rope is thrown to her, the pilot ties it round his body, plunges into the sea, and is hoisted on board. The danger is now past, and in half an hour more we are safely at anchor, deeply thankful for our narrow escape from the horrors of shipwreck.

Now this incident has actually occurred more than once, and has only too frequently ended in the loss of ship and crew. Excellent charts for this coast are published by the Norwegian Government, but as far as English seamen are concerned it is but little better than explored. The Norwegian charts, with a book of sailing directions in manuscript and slip, are at this moment lying unused on the shelves of the Hydrographical Office. Why are they not published? Because, for 'departmental reasons'—mark the phrase—it has been decided that they are 'to stand

over.' Of these, and similar documents, we may say, in the words of the old Scotch song, that

> Wives and mithers maist despairin'
> Ca' them lives o' men.

Apart from humane considerations, the new branch of commerce that has been opened in Siberia, and our increasing trade with Norway, which is already worth nearly five millions a year, would appear to justify the small additional outlay that would be required to publish work that has already been done, and paid for. I am quite sure that neither the Government nor the public have realised the state of things that I have endeavoured to set before you, and that if it could only be made clear to them, fewer ships would be wrecked on the dangerous shoals called 'departmental reasons.'

I hope I have succeeded in proving that hydrographical information is urgently needed by our merchants, and by their fleets, while the fate of the *Independencia*, and the narrow escape of the *Active* and *Tenedos*, clearly show that it is required by our Navy. Both duty and interest call upon us to provide this information to the utmost extent of our power, for hardly a ship floats that does not in some way carry British interests, and, as the First Lord of the Admiralty publicly said only a few weeks ago, 'our national greatness is principally due to the fact that we have a larger mercantile marine than any other nation.'

In the words of a great English Minister, 'I refer it alike to the hearts and understandings of those who hear me, and of those out of doors who will consider our discussions, whether we should not shrink from our duty, and disgrace the memory of those who have gone before us, if we were to hesitate to say that we would provide for the wants of the day in which we live? I am not addressing you in unconsciousness of the increase made to the Army and Navy Estimates, which unforeseen circumstances have rendered of immediate necessity, but in considering the amount of estimates voted, I would say, it is not the amount to be considered, but the national exigencies imperatively required for the country's safety.'

This is essentially a humane and industrial, and in no way a party question, and I would earnestly appeal to you to use your influence for the restoration of the Surveying Service to the prominent position it ought to hold among the forces of civilisation, and to protect it in some measure from those blasts of ruinous economy which occasionally sweep over our country. By increasing the number of surveying ships, and extending to navigation and nautical surveying a fair share of the encouragement so freely bestowed on ship-building and great-gun-founding, you would establish a first-rate finishing school, which would produce not only nautical surveyors, but superior officers for the general service; and, in giving your naval officers the opportunity of practising afloat what they learn at Greenwich, you would enable them more efficiently to protect the trade they would be helping to extend.

I trust that the country will take this matter up; that before long the commander-in-chief of every station will have a properly equipped surveying ship at his disposal; and that the Hydrographical Department may be extended to enable it to keep pace with the wants of the times, and to publish and circulate the stores of valuable—or rather invaluable—information, that are now shelved for 'departmental reasons.' While

occupied in exploration and discovery, our officers and men would escape the idleness engendered by a long interval of peace; that idleness which, like a slow poison, little by little wears away the strength and valour of a nation. They would be advancing civilisation, extending knowledge, and exciting friendly interest and sympathy throughout the world, thus helping to consummate the high aspiration—

> That England may still be respected and free,
> The envied of nations, the Queen of the Sea.

Indicates
Vessels n

✠ Indicates stations of detached Government
Surveying parties, working in hired vessels.

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TRANSACTIONS OF THE SECTIONS.

TRANSACTIONS OF THE SECTIONS.

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

President of the Section.—G. Johnstone Stoney, M.A., F.R.S., M.R.I.A.

THURSDAY, AUGUST 21, 1879.

The President delivered the following Address:—

In order that we may understand the present position of Natural Science upon the Earth, we must remember that the universe is in itself one great whole, which includes minds no less than bodies, for thought is as much a phenomenon of what really exists as motion. But though the universe be but one, man with his limited powers is unable to treat it as such, but has to push his investigation of Nature when and where he can. Thus have arisen many sciences which were at first quite isolated. Their separate condition is a mark of the feebleness of our powers of investigation. Their gradual convergence, and especially where any complete contact can be established between them, is the mark that our advancing knowledge is penetrating deeper.

That there are many sciences of Nature, instead of one science of Nature, has its relation, then, to human imperfection. But the coalescence of sciences has commenced, and is steadily taking place; magnetism is no longer isolated from electricity, nor light from heat, nor the power of thinking from the condition of the brain. In all such cases we have got nearer to understanding what is really going on in Nature. There are already many such achievements of science; but, nevertheless, it remains true that human powers of investigation are so narrow, and the use we have made of them up to the present is so short of what we may reasonably look for in the future, that the sciences of Nature are still many, and most of them stand lamentably aloof from one another.

We find, then, in the present passing condition of our knowledge, one group of sciences which investigate the phenomena of consciousness; another distinct group of the biological sciences; and a third, the group of the physical sciences. These are all but parts of the one great investigation of Nature, but for the present they exist almost disconnected, as separate provinces of human inquiry.

When we endeavour to investigate mental phenomena, we are encountered by the complexity and remoteness of the effects which present themselves for examination, and by a deep and unpenetrated obscurity hanging over the interval between them and their causes. In order to make any progress even in the subordinate task of tracing out the relations of these effects to one another, the inquirer finds it necessary to venture upon hypothesis, and in all metaphysical speculation we sadly miss that healthy discipline with which Nature in other branches of science relentlessly refutes our hypotheses if they are wrong. Here, then, is a region in which the plausible may be mistaken for the true; and it is unfortunately certain that it has sometimes been so mistaken by the ablest human minds.

The biological sciences treat of all the phenomena of living beings, except their mental phenomena, which are those which lie most remote from their causes. Here the complication is less, but it is still too great for the human mind to have yet penetrated behind it. We are still occupied with phenomena which lie at a great distance from their real causes. We are accordingly still far beyond the range of the exact sciences. Most of the great discoveries of biological science have been made by estimating the *general drift* of what is taught by a vast number of particular facts. This, it will be observed, is a kind of reasoning that is necessarily more or less inexact,[1] and, as a consequence, it is one which requires wide intellectual training and great experience and tact to handle it with safety. When the investigator has brought these qualifications to his task, astonishing progress has been made in these sciences: without them the reasoning may degrade into being either trivial or loose.

In the rest of the study of Nature we are not embarrassed by the phenomena of life, and many mysteries therefore stand aside out of our path. Here lies the domain of the physical sciences. It is here that the mind of man has best been able to cope with the realities of the universe, and in which its greatest achievements have been effected. It is here that exact reasoning finds a predominant place.

The study of the physical sciences has been remitted by the British Association to its first two sections, chemistry being assigned to Section B, and the rest of the physical sciences to Section A. Accordingly, Section A includes the whole range of mathematics, along with the study of the conditions of rest and motion in that part of matter which is endowed with mass, and of the phenomena of sound, heat, light, and electricity, with the applications of these abstract sciences in molecular physics and to astronomy, crystallography and meteorology.

In meteorology, owing to the complication of the materials that have to be dealt with, we must have frequent recourse to the same kind of reasoning as has been found so effectual in the biological sciences; but in the other physical sciences which I have enumerated exact reasoning prevails, and on this account they are frequently classed together as the exact sciences.

The process of investigation in the exact sciences is fundamentally one in all cases. It has been well described by Mill in the third book of his 'Logic.' Nevertheless, it is notorious that minds which are well fitted for some branches of physical inquiry find difficulty—sometimes insuperable difficulty—in pursuing others. It is not every eminent mathematician who would have made an equally good chemist, or *vice versâ*. This is because there exists a practical distinction separating the investigations of exact science into two well-marked classes when they are viewed, not as they are in themselves, but in their relation to the powers of us human beings. I refer to the distinction between the experimental method or the method of observation, on the one hand; and the deductive method, or the method of reasoning, on the other. All valid investigations in exact science appeal to what can be directly perceived, and all lead to a conclusion which can be reasoned out from it; but there are some of these investigations in which the main difficulty consists in making the appeal to the senses, and there are others in which the main difficulty lies in the process of reasoning.

To contend with these difficulties successfully requires very different qualities of mind and body. In experimental science the powers principally called into requisition are readiness and closeness of observation, dexterity in manipulation, skill in contriving expedients, accuracy in making adjustments, and great patience. It also requires that the investigator should have an accurate memory of what else he has witnessed resembling the phenomenon under observation, that he should be quick to detect every point of agreement and difference that can be perceived, and be skilful to select those which are significant, and to employ them as materials for prevision to guide his further proceedings. But the strain on the reasoning

[1] Except when the reasoning takes a form in which its strength can be gauged by the doctrine of probabilities. The most satisfactory instance of this is that 'statistical method' which has proved our most searching tool in molecular physics.

powers is generally less, often of trifling amount. The question is put to Nature, and it is Nature usually that gives the bulk of the answer. The most striking monument of splendid achievements by the experimental method of investigation unaided by the deductive method is to be found in the science of chemistry.

An equally typical instance of the power of the deductive method is the science of mechanics. This science, which has sunk deeper into the secrets of Nature than any other science, and which is the science towards whom all other physical sciences are at present more or less gravitating, is essentially deductive. There is little or no difficulty about its fundamental data. They are facts of Nature so patent to all men, and so indelibly implanted in human conception, that some persons have supposed that we have an intuitive perception of them. But, while the materials from which the mind is to work are thus easily obtained, it has taxed to the utmost the reasoning powers of understandings like Newton's to evolve the few consequences of them which are already known, and the investigator has to call to his assistance every aid to prolonged consecutive thought which mathematicians can devise.

In grappling with the problems of Nature we are seldom allowed the choice of the method of investigation we shall employ. This is commonly settled for us and not by us. Where we cannot advance without further information, we must make further observations, *i.e.*, we must employ the experimental method, the appeal *ad experientiam*: where we cannot advance without understanding better what the information we possess really amounts to, we must employ the deductive method.

No reach of intellect applied to the materials in existence before 1860 could have elicited the fact that iron exists upon the sun. This great discovery was made by Professor Kirchhoff, a scientific man who was equally versed in both methods of investigation. On the present occasion it was the experimental method he employed. He applied to the scrutiny of the sun's spectrum four prisms of the most homogeneous glass that could be procured, figured with the greatest accuracy that the eminent artist Steinheil could attain. He expended far more pains on their adjustment for each successive part of the spectrum than any of his predecessors had done, and he was rewarded by a more perfect vision of the sun's glorious spectrum than had met the human eye before. In a collateral inquiry, suggested by an observation made by Foucault, he and Bunsen placed a metallic vapour emitting bright rays in front of a still brighter incandescent body, so that the light from the brighter background had to pass through this vapour, and they found that the vapour now caused dark lines in the spectrum occupying the positions which its own bright lines had before filled. Professor Kirchhoff thereupon added an appliance to his spectroscope which enabled him to bring a metallic spectrum and the solar spectrum together into the field of view, alongside of one another. On accomplishing this he saw sixty of the brightest of the iron rays as continuations of sixty of the strongest of the dark lines in the sun's spectrum; and, by an elaborate scrutiny, he satisfied himself that the observations had been pushed to a sufficient degree of exactness to make sure that a deviation would have been detected in any one of these sixty cases if it had amounted to as much as one-fourth of the average interval between consecutive lines of the solar spectrum. From this it was obvious that the sixty coincidences are not due to chance, but indicate that there is really iron vapour in the path of the rays. It will be observed that Kirchhoff's great merit and the real difficulty of his work lay in the scientific foresight and the industry which were required to frame hypotheses that were worth testing, to guide the investigation by these hypotheses, to contrive, construct, and adjust adequate apparatus, and to make with it the elaborate observations and the exact observations and maps which were necessary. But when by these means the new facts had been brought to light, the inference from them that there is iron in the atmosphere of the sun was an easy one. This example will better convey than a definition what are the characteristic features of an experimental inquiry.

On the other hand, no series of observations or experiments, however skilfully arranged, could have enabled anyone to understand the cause of that familiar but truly surprising phenomenon that a top stands upon its peg while it is spinning.

But a full explanation of it is within the reach of any student who will train his mind to reason consecutively, and avail himself of the aids to prolonged consecutive thought which mathematicians have contrived. He will then see that the most obvious and familiar mechanical facts involve as necessary consequences all the phenomena which he finds in the schoolboy's top, in the physicist's gyroscope, and in the precession and nutation of the heavens. This then is a problem of Nature which falls within the province of the deductive method.

Wherever data are known exactly, there inferences from these data however remote may be depended upon as corresponding with what actually occurs in Nature. And if in such cases the mind of man has proved equal to the task of drawing inferences which can effectually grapple with the problems he finds around him in the Universe—which is, alas! as yet but too seldom—then will the deductive method, our plummet, explore depths in the great ocean of existence which our anchors of experiment could not have reached.

The distinction which is here made between deductive and experimental investigations would have no place in a logical system. But it has direct reference to human convenience, and derives its importance from this circumstance. It is obvious, too, that an investigation may partake of both characters—that it may require all the powers of the scientific observer to get at the facts, or even to appreciate them, and all the resources of the mathematician to elicit the consequences of them. For instance, on beginning his electrical studies, the student of Nature must master a mixed experimental and deductive inquiry to get at the elementary fact that free electricity resides either at or outside the surfaces of conductors; and he must engage in a further inquiry, and one only within the reach of a trained mind, to deduce from this the law of the inverse square. And, again, no full appreciation or even intelligent use of the common electrostatic and electrodynamic measures which he meets at the threshold of his electrical studies is within the reach of the mere experimentalist or of the mere theorist. And if this treacherous ground lies before the immature student at his entrance, what shall we say of the bogs he struggles into as he advances. We are perpetually meeting with inquiries of this mixed character in electricity and some of the other physical sciences, but they are comparatively rare in either mechanics or chemistry, and none that is difficult lies in the path of the beginner. How many students are there who are made to slur over the above and a multitude of similar difficulties, and who are told that they are learning science, when in fact what they are really learning is the pernicious habit of being content to see Nature through a fog or through other men's mental eyes.

In mechanics valuable progress can be made by the mere mathematician, the student of deductive science; and in chemistry similar progress can be made by the mere experimentalist. Of all the physical sciences these are the most purely deductive, and the most purely experimental. What I desire particularly to invite attention to is that the two great methods of investigation may best be acquired in these two sciences, and that for a really sound grasp of the remaining physical sciences, and especially with a view to further advance in physical science, a command of both methods of investigation is essential. I ought to add, however, that to confer this inestimable boon on the investigator of Nature, the great science of mechanics must be studied by him in its own best form, and not degraded by the vile expedient of evading the legitimate use of the infinitesimal calculus, to comply, perhaps, with the ill-judged requirements of some examining body; and his practical chemistry must be the study of a science, and not a mere accumulation of exercises in a lucrative art.

We must bear in mind, too, that either method of investigation may be misapplied, and that this is a risk carefully to be guarded against. The deductive method when misapplied lands us in speculation, the experimental method becomes empiricism; and it so happens that the sciences of mechanics and chemistry are not only monuments of the power of the two great methods of investigation, but instructive examples of their weakness also. For in chemistry, scarce any attempt at prolonged reasoning, carrying us by any lengthened flight to a distance from the experiments, can be relied on. The result has seldom risen to anything better

than speculation. And on the other hand, in mechanics, conclusions which depend on experiments only are empirical; that is, they are deficient in accuracy, and their relation to the other phenomena of the science is left in darkness. Here, then, we find in these two sciences not only how strong these two methods of investigation are, but how weak they may become if misapplied.

I do not know whether any of my predecessors in this chair have experienced so much difficulty, or have hesitated so long and so much as I have hesitated in selecting the topic to which he would ask your attention. My first effort was an attempt to delineate the great recent progress of the mathematical and physical sciences, but it was unsatisfactory, partly from my own too scanty powers, and also because the variety and even disparity of the numerous sciences somewhat arbitrarily grouped together in Section A gave to the outline too sketchy a character. My next attempt was to make a selection among them, confining myself to those with which I am best acquainted, and endeavouring to direct attention to the problems which at the present time seem most to stand in need of solution. But here I felt unwilling either to bring forward or to withhold views which might be disputed. I then applied myself to the single consideration of what I hoped might prove useful and not inopportune at a time when one university, which I trust will prove a great university, is rising in the north of England, and when another university which has carefully and successfully fostered a high standard of education for thirty years, and which has thereby deserved and won the respect of educated men, has just been sacrificed to ecclesiasticism in the sister isle. In this university I have held the most central office for twenty-two years, and in the discharge of my duty had largely to influence its destiny in respect to almost every educational problem. Parliament in its wisdom has now seen fit to destroy this work, and I have not been without hope that from the experience which has been gained some effect which shall last may yet arise, and that the Queen's University may perhaps at its extinction bequeath a useful legacy to the University of Victoria. The advancement of science in the north of England will largely depend for many years on the wisdom of the regulations for scientific training which are adopted at first by the new university; and I have therefore ventured, at this peculiar juncture, to submit to the judgment of my scientific brethren the principles which much thought and many trials extending over several years have led me to believe should guide them in selecting this part of a curriculum.

I have sought to show that it is in the study of mechanics and in the practice of chemistry that the two great methods of investigation may best be acquired. In them they may be studied separately, by steps of graduated difficulty, and with a superabundance of materials; and each of them supplies the necessary cautions with respect to the method which is all powerful in the other. No scientific man is really equipped for the pursuits in which both methods have to be employed till he has separately acquired a grasp of each. For it is only then that he will be armed against the errors which lead so many to mistake empiricism on the one hand and speculation on the other for solid science, or to underrate solid science mistaking it for speculation. Nor is it only in his scientific occupations that he will derive benefit from this training. All exact reasoning, whether in science or in common life, belongs to these great divisions; and in the numberless instances in which we must be satisfied with reasoning which falls short of being exact, our only safety lies in having by the practice of exact reasoning, both deductive and experimental, attained to that intellectual tact and caution which alone will enable us to handle with safety the sharp and slippery tool. It is thus that a sound judgment with regard to truth may best be acquired by man or woman; and soundness of judgment is the noblest endowment of man's understanding, just as veracity stands first among his virtues.

The following Reports and Papers were read:—

1. *Report of the Committee for commencing Secular Experiments upon the Elasticity of Wires.*—See Reports, p. 33.

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2. *Report of the Committee for making more Accurate Determinations of the Mechanical Equivalent of Heat.*—See Reports, p. 36.

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3. *On Etherspheres as a* Vera Causa *of Natural Philosophy.* *By* Rev. S. Earnshaw, *M.A.*

The author of this communication, assuming an admitted parallelism between the phenomena of light and heat, proceeds by means of three hitherto overlooked propositions in natural philosophy to establish the universal existence of what he has denominated *etherspheres*, the third of his propositions being—'Every atom of matter in the universe is surrounded by an ethersphere of its own.' The following is the system of nature which he finds sufficient for his purpose:—

1. In nature there are two distinct substances, matter and ether, neither of which has any power to attract or repel the other.

2. Matter consists of atoms which attract each other with forces varying according to the Newtonian law $(\text{distance})^{-2}$.

3. The atoms of bodies of the same kind are alike in all respects; atoms or bodies of different kinds differ from each other in size, and possibly also in other respects, such as shape, &c.

4. Atoms, whether of matter or of ether, are incapable of experiencing any change of figure or dimensions; and they are all assumed to be of such geometrical forms as cannot fill space.

5. From the phenomena of light it has been inferred that atoms of ether repel each other with a force varying as $(\text{distance})^{-4}$.

6. Every atom of matter is impervious to ether, and acts on ether in no other way than by pressure of contact.

7. A portion of space filled with matter is necessarily void of ether; and all space void of matter is pervaded by ether.

8. The enormous velocity of light in free space has led to the opinion that very great must be the repulsive power of ether on ether; and it seems to follow from this that an ether atom will experience great difficulty in moving from one part of the ethereal medium to another. Except as waves and currents ether motion will be under great restraints, and especially shall we see this when we also remember the high power $(^4)$ of its inverse law of force.

9. In free space light is believed to be transmitted with the same velocity in every direction, and from this we infer that the atoms of ether are all spherical in form.

The following is the author's definition of an ethersphere:—

All space not filled by matter is pervaded by ether, so that every atom of matter is surrounded by ether, but this is not what is included in the word 'ethersphere.' The author shows that if any portion of space be rendered void of ether from any cause whatever, that space has become void of the repulsive forces which were centred within it, and that, consequently, when these forces are taken away the medium outside the space will draw closer towards that space; and if the space be occupied by an atom of matter, the density of the surrounding ether will be greater than before, and the ether, being in contact with the atom at its surface, will press upon it. This *excess* of ether about the vacant space above its original quantity constitutes the ethersphere; and though this gathering together of ether

about the space now occupied by the atom is a consequence of the presence of the atom, it is in no way owing to its action on the ethereal medium.

The author then argues that if every material atom, so must every compound system of atoms, *i.e.*, every material body, whether gaseous, liquid, or solid, have an ethersphere, which not only surrounds the whole body, but also penetrates the interstitial spaces of the body which lie between its atoms.

By means of these etherspheres the author believes the phenomena of heat may be satisfactorily accounted for, on the supposition that the ethereal medium is the medium of heat as well as of light. They are shown in the original memoir itself to have a remarkable bearing also on the phenomena of magnetism, electricity, galvanism, and the various sciences connected with the agency of imponderables. He therefore concludes that etherspheres constitute a *vera causa* the existence of which in nature is as certain as is that of the ethereal medium itself, about which no philosopher expresses doubt in the present day.

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4. *On some New Instruments recently constructed for the continuation of researches on Specific Inductive Capacity.* *By* J. E. H. Gordon, *B.A.*, *Assistant Secretary of the British Association.*

Mr. Gordon exhibited and explained the following new instruments which he has arranged during the last year:—

(1) A minature five-plate induction balance, similar in principle to the large balance exhibited at the Dublin meeting, but intended for the examination of crystals and other precious substances which cannot be obtained in sufficiently large quantities for the large balance.

The large balance requires the dielectric plates to be 7 inches square and $\frac{1}{2}$ to $\frac{3}{4}$ inch thick. For the small balance it is sufficient to make them 2 inches square and $\frac{1}{8}$ inch thick.

(2) A gauge for measuring the thickness of the dielectric plates to $\frac{1}{10000}$ inch.

(3) A new form of quadrant electrometer for use with the small induction balance.

The capacity of the smaller plates of the little induction balance is so minute that when they are attached to the quadrants of the electrometer of ordinary construction (Elliott pattern) disturbances in them produce hardly any effect on the needle, on account of the much greater capacity of the quadrants of the electrometer.

In order to construct an electrometer whose quadrants should have very small capacity, and which should yet be very sensitive, the author has arranged the quadrants as pieces of a flat disc, only one inch in diameter, and the needle has been bent round them so as to be acted on by both their upper and lower surfaces and their outside edge.

(4) A new rapid commutator.

This was invented by Professor Cornu, of the École Polytechnique, Paris, who had the great kindness to devise it for the author of this paper, who, when M. Cornu took up the matter, had just constructed three different instruments for the experiments for which this one is intended, all of which had proved unsuccessful.

Some preliminary experiments with M. Cornu's instrument have shown that it promises to be entirely satisfactory. It can be used with either the large or small induction balance on the one hand, and with a Holtz machine or battery of 500 or more cells on the other. It reverses the electrification of the plates of the balance eighteen times per second, and between each reversal, short circuits, and puts to earth both poles of the induction balance and both poles of the battery. By altering two screws it can be arranged to short circuit and put to earth the poles of the induction balance only, and to insulate the battery poles.

(5) Driving-wheel for the Cornu commutator.

All the instruments have been constructed by Mr. Kieser of the firm of Elliott Brothers.

5. *On Secular Changes in the Specific Inductive Capacity of Glass.* By J. E. H. Gordon, *B.A., Assistant Secretary of the British Association.*

At Christmas 1877 I made some determinations of the specific inductive capacity of optical glass by a method which has already been fully described both before this section and elsewhere.[1]

At the end of July 1879 I commenced a repetition of the experiments, using the same slabs of glass, and was surprised to find a large increase in the specific inductive capacity in every case. In some cases the increase was as much as twenty per cent.

The following is a table of the results:—

Specific Inductive Capacity of Optical Glass.

	Christmas, 1877	July and August, 1879
Double extra dense flint. . . .	3·164	3·838
Extra dense flint	3·053	3·621
Light flint	3·013	3·443
Hard crown	3·108	3·310

The arrangement of the apparatus, including the coil and rapid break, was precisely the same as in my earlier experiments. The electromotive force was as nearly as possible the same, and experiment has shown that moderate variations in it do not affect the results.

The differences observed might have been caused by any one of three things:—

(1) By error in the 1879 experiments;

(2) By error in the 1877 experiments;

(3) By a change in the specific inductive capacity of the glass between Christmas 1877 and July 1879.

Careful repetition of the 1879 experiments has convinced me that there is no error in them.

If the difference is caused by error in the 1877 experiments, then in 1877 I must have obtained too low a result. With my induction balance the effect of covering the dielectric with a well-conducting film is to prevent observation; the effect of covering it with a badly-conducting film is to give too low a result.

Before rejecting the second explanation of the difference, based on the hypothesis of error in the 1877 experiments, it is therefore necessary to prove that in 1877 there was no film on the surface of the glass of sufficient conducting power to cause a large error in the results.

In 1877 the glasses were not washed by immersion in water, but were thoroughly cleaned with a glass-cloth and wash-leather. To the best of my recollection they were first rubbed with a damp cloth, then with a dry one, and then polished with the leather, being frequently breathed on during the process, and then usually warmed at the fire. This process was so far efficacious in removing any conducting film of moisture from the glasses, that at the end of it they were usually found to be electrified by the friction of the leather. When this occurred they were passed rapidly a few times over the flame of a spirit-lamp to discharge them. They were always so warm that any visible moisture deposited by the spirit-lamp disappeared instantly.

In the 1879 experiments, which are quoted in the preceding table, the glasses

[1] *Report Brit. Assoc.*, 1878; *Proc. Roy. Soc.*, 191, 1878; *Phil. Trans.*, 1879; *Four Lectures on Electric Induction*, delivered at the Royal Institution (Sampson Low & Co.), 1879.

were washed in hot water, wiped and polished, and passed over the spirit-lamp while still hot. After observing a difference in the first two specimens examined, I made preliminary experiments on the other two before cleaning them. The following are the results obtained:

HARD CROWN GLASS.

	S.I.C.
Christmas 1877	3·108
August 7, 1879.—Not wiped for more than a year; placed in balance covered with dust exactly as taken from box, which does not shut airtight	3·236
August 8.—Cleaned in hot water, as described above	3·310

LIGHT FLINT GLASS.

	S.I.C.
Christmas 1877	3·01
August 4, 1879.—Dusted lightly with duster, not rubbed	2·90
August 4.—Cleaned in hot water, experimented on while hot	3·44
August 4.—Cooled under tap, wiped with glass cloth	3·44
August 5.—Had stood twenty-four hours uncovered on table, not wiped	3·39
August 5.—Smeared all over with oil	3·48
August 5.—Smoked on oily surface over paraffin lamp, so as to make glass semi-opaque	3·46
August 5.—Glass made very wet with solution of sal-ammoniac	Experiment impossible
August 5.—Roughly dried with duster; surface appeared opaque, like ground glass	1·64
August 5.—Wiped over with glass-cloth, but not rubbed	2·36
August 5.—Rinsed under cold tap, and wiped with glass-cloth, but not polished	3·46
August 5.—While still cold, passed over spirit-lamp till much more clouded than ever would be the case in actual work; placed in balance, and experiment made as quickly as possible	3·48

My conclusion from the above numbers is, that although it is possible by sufficiently wetting the surface of the plate to produce any apparent reduction of the specific inductive capacity, yet that even if very much less care had been taken to clean the plates than was taken in 1877, the greatest quantity of moisture that could accidentally have been left on them would have been totally incapable of producing anything like the difference now under examination.

I am therefore led to the conclusion that in the course of a year and a half an actual change has taken place in the glasses, which is shown by a considerable real increase in their specific inductive capacities. To complete our knowledge of this new phenomenon we require a series of monthly observations, extended over perhaps a period of several years. I shall hope to be able to give the results of another year's experiments at the next meeting of the Association.

These experiments have some importance as regards Professor Clerk Maxwell's electro-magnetic theory of light. In a recent lecture[1] I ventured to suggest 'that it is quite possible that the relation between electric induction and light exists—namely, that they are disturbances of the same ether, but that there is some unknown disturbing cause affecting the electric induction.'

Possibly a clue to the nature of this disturbing cause may be found in the fact, that the specific inductive capacities are affected by some of the changes which chemists tell us are constantly going on in glasses, but that these changes do not affect the refractive indices.

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6. *On the Cause of Bright Lines in the Spectra of Comets.* *By* G. JOHNSTONE STONEY, *M.A., F.R.S., M.R.I.A.*

Dr. Huggins and other observers have seen the bright lines of some compound of carbon in the spectra of several comets. This establishes the fact that a compound of carbon is present in the comets. It is always assumed in what has been

[1] Royal Institution, February 6, 1879.

hitherto written on this subject that the vapour which has thus been detected is incandescent because it emits these bright lines.

The author of the present communication wishes to put forward an alternative hypothesis, which he believes to be entitled to much weight. It is that these lines are due to the sun's light falling upon the compound of carbon, and rendering it visible in the same way that light renders other opaque objects visible, the vapour being opaque in reference to the particular rays which appear as bright lines in its spectrum.

An opaque body is visible in the presence of a luminary from three causes—because of such a scattering of the incident light as takes place when a transparent body is reduced to powder; because of the reflection of light from its surface if of sufficient extent and sufficiently smooth; and because of phosphorescence. Bequerel has shown that phosphorescence contributes to render objects visible in a vast number of instances, and it is this which seems to produce the effect in the case now under consideration.

Phosphorescence consists in the exaltation of such molecular motions by radiant heat as are unable readily to communicate their superfluous energy to the other kinds of motion which are going on in or among the molecules. The motions within the molecules of gases stand in this predicament if the intervals between the encounters of the molecules are sufficiently long. Now in comets, on account of their small mass, the vapour must be excessively attenuated, and these intervals must be proportionately long. Hence the conditions are such as will eminently promote phosphorescence, and therefore visibility, in the presence of a luminary.

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7. *Sur le Maximum d'Intensité du Spectre Photographique Solaire. Par le* Dr. J. Janssen, *de l'Institut de France, Directeur de l'Observatoire de Meudon.*

Cette communication est la suite des recherches sur ce sujet, et qui remontent à 1874. Dès cette époque j'avais reconnu que le spectre solaire présentait un maximum d'intensité situé au delà de F vers le violet.

Depuis à diverses reprisès j'ai communiqué le résultat de ces recherches, qui ont été fréquemment interrompues. (Voir les notices de 'L'Annuaire du Bureau des Longitudes,' 1878, 1879, et le 'Report of British Association,' 1878.)

Les parties nouvelles de ce travail concernent l'examen des diverses substances photographiques et des divers milieux optiques, et surtout l'emploi d'une nouvelle méthode d'étude du spectre par la variation du temps de pose et que je propose de nommer analyse chronométrique du spectre.

Méthode d'Analyse Chronométrique du Spectre.—Cette méthode consiste à faire passer devant la fente d'un appareil à photographier le spectre, et *pendant la pose* un écran en forme de triangle, qui, par le progrès de son mouvement, vient masquer successivement les diverses parties du spectre dans le sens de sa hauteur; en sorte que si l'on considère deux lignes ou bandes brillantes du spectre ces lignes prendront dans la photographie des longueurs en rapport avec leurs intensités lumineuses.

En effet si l'on considère le spectre dans un sens perpendiculaire à celui de ses lignes spectrales ou de la fente, on reconnaîtra que les points dans cette direction reçoivent une pose égale, que cette pose est au contraire de plus en plus grande à mesure qu'on marche dans le sens perpendiculaire dans la direction des raies et vers les parties que l'écran triangulaire couvrira les dernières.

Le mouvement de l'écran triangulaire est donné par un rouage d'horlogerie et doit pouvoir prendre des vitesses variables.

L'écran triangulaire rectiligne peut être remplacé par un triangle dont l'hypothénuse est une courbe de forme déterminée pour produire une pose variant suivant une loi déterminée.[1]

[1] Cette méthode permet de mettre en évidence et de mesurer les intensités photographiques des divers points des spectres par la considération des longueurs des lignes ou bandes dans leurs images photographiques. Elle pourra être spécialement employé à la question de la présence des lignes brillantes de l'oxygène dans le spectre solaire.

Maximum du Spectre. Expériences.—Les études qui ont mis en évidence ce maximum sont les suivantes :—

On a employé des spectrographes formés avec prismes et lentilles de quartz, de spath d'Islande, de crown, de flint, et aussi des réseaux pour produire le spectre.

Les substances photographiques employés sont les collodions aux iodures et bromures de potassium, sodium, ammonium, zinc, cadmium. Ces substances ont été essayées soit isolément soit associées.

Pour la pose : on s'est procuré relativement à chaque disposition d'expérience une série de spectres depuis cinq minutes de pose jusqu'à une fraction de seconde.

On a aussi employé la méthode des écrans à marches et la méthode chronométrique décrite plus haut.

Résultats.—Ces études ont conduit à reconnaître qu'il existe un maximum d'action dans le spectre solaire.

Ce maximum est situé près de G.

Il est un peu variable d'étendue avec les substances photographiques; les bromures lui donnent plus d'étendue que les iodures.

Il est toujours très limité, et pour des poses courtes et bien déterminées il se traduit par une étroite bande près de G.

Certains flints le réduisent encore, et il devient presque une ligne.

Ces conclusions ne visent que les conditions expérimentales décrites.

Conséquences.—L'existence d'un maximum très-limité dans le spectre photographique du soleil conduit à des conséquences dont on énumère ici quelques-unes.

1. Elle montre qu'on peut obtenir de bonnes photographies du soleil avec des lentilles simples, si elles ont un long foyer et si elles sont formées avec un flint donnant le maximum très-limité dont nous avons parlé.

2. Elle explique comment il a été possible d'obtenir par la photographie des images de la surface solaires donnant des détails et révélant des phénomènes que les lunettes ne peuvent montrer, car l'achromatisme photographique peut être beaucoup plus parfait que l'achromatisme oculaire. Il y a aussi à tenir compte du temps de pose de ces images, qui est d'environ $\frac{1}{3000}$ de seconde, ce qui empêche l'action des perturbations atmosphériques.

On comprend en outre l'importance de la découverte de ce maximum pour la construction des objectifs et appareils optiques de la photographie. On devra y avoir égard dans la recherche de l'achromatisme des objectifs si l'on veut avoir une très grande perfection.

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8. *On the Changes of Volume in Iron when passing from the Liquid to the Solid State, and on an Instrument for observing the same. By* T. Wrightson, *Memb. Inst. C.E., F.G.S.*—See Section G., p. 506.

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9. *On the Isophotal Binocular Microscope. By* Samuel Holmes.

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10. *Some Observations on Generic Images. By* W. Cave Thomas, *F.S.S.*

At the first Art Congress held in Antwerp many years since, in propounding the theory, that the average or mean form, was, according to probability and experience, the fittest form of the species, and in man the form of beauty, I attempted to demonstrate the truth of the theory by experiment, though with very imperfect appliances. I again alluded to the matter in one of my earliest published works, 'The Science of Moderation,' and expressed my conviction that the demonstration would be more completely effected at some future time, as appears to have been done by Mr. Francis Galton in his 'Composite Photography.'

The rationale of such experiments is simply this, that we perform a mechanical averaging. Instead of any one object being presented to our gaze, we have a *mean* image, in which proportions of excess and defect have mutually neutralised each other. It is true that in photography the process is very limited; it can deal but

with a few individuals, but on that sensitive surface, the retina, a vast range of individual images of the same species may be impressed, but as excesses and defects neutralise each other, the mean or average image is most forcibly impressed on the mind, and that image constitutes our ideal. We arrive at the idea of beauty in precisely the same way that we arrive by a series of observations at the true place of a star. But it is not necessary, in order to illustrate the mental process by a mechanical process, that we should photograph human beings. We may take geometrical forms, such for instance, as the genus ellipse, whose transverse and conjugate axes may vary between the limits of 1 : 1 and 1 : 0. The diameters of the mean ellipse, parallelogram rhombus, and oviform are as 1 : 2, a proportion in these figures which has been a favourite one through the ages. The genus ellipse may be divided into species, any one of which may be experimented with, for instance the species lying within the limits of 1 : $1\frac{1}{4}$ to 1 : $1\frac{1}{3}$, or of 1 : $1\frac{1}{2}$ to 1 : 2, &c. I propose to photograph the impression which such figures would make through an aperture in a revolving disc.

FRIDAY, AUGUST 22, 1879.

The following Reports and Papers were read:—

1. *Report of the Committee for Procuring Reports on the Progress of Mathematics and Physics.*—See Reports, p. 37.

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2. *Report of the Committee on Underground Temperature.*
See Reports, p. 40.

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3. *Report of the Committee on Atmospheric Electricity at Madeira.*
See Reports, p. 63.

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4. *On the Retardation of Phase of Vibrations transmitted by the Telephone.* *By* Professor SILVANUS P. THOMPSON, *B.A., D.Sc.*

It was predicted from theoretical considerations by Dubois-Raymond that a difference of phase, amounting to a quarter of a complete vibration, would be found to exist between the diaphragms of two associated Bell telephones, the receiving telephone being a quarter of a vibration behind the transmitter. A more complete theory, worked out independently by Helmholtz and Weber, gave a somewhat contradictory result, and required only a small difference of phase. Recently König, in a series of delicate experiments, effected an optical comparison by the method of Lissajons of the vibrations of a pair of telephones, replacing the vibrating discs by tuning-forks armed with mirrors. The experiment is a delicate one, and is performed under conditions not free from objection. The author has proposed the following method of observing. A pair of Bell telephones are suspended by wires of about a metre in length, so as to oscillate as pendulums, to frames so disposed as to avoid the possibility of any mechanical transmission of the vibrations. Below the point of rest of each telephone, and at some little distance from it in the plane of its swinging, is placed a steel magnet. After the lengths of the wires have been so adjusted that the telephones will swing in identical periods, one telephone is set swinging. As it alternately approaches and recedes from the magnet, the induced

currents traversing the second telephone set it swinging. In every case the difference of phase observed amounted to one quarter.

In the case of those telephones which transmit vibrations by varying the resistance of the circuit, instead of varying the electromotive force, there is no such retardation of phase produced in the ordinary electromagnetic receiver. If, however, the current so transmitted is first passed through an induction coil, a retardation of phase of one quarter is produced, and in the case of several successive inductions the retardation amounts to an additional quarter for every additional induction. This remark applies only to vibrations of harmonic and quasi-harmonic type. Vowel sounds, which consist of compound harmonic vibrations, are unchanged to the perception of the single ear, which is unable to distinguish differences of phase, or between compound sounds which differ from one another only in the difference of phase of their components. The vibrations of consonantal sounds, on the contrary, depart more and more widely from their original type at each successive induction.

In the case of Edison's motographic or electro-chemical receiver, the velocities, not the displacement of the disc, are proportional to the strength of the currents received. Hence vibrations already retarded one quarter in transmission, as is the case with those of the carbon transmitter in conjunction with its induction coil, always used with this instrument, are restored to their primitive phase. The vibrations of this receiver therefore agree in type, not with the vibrations of the induction current (which correspond to the derived function of those of the original vibration), but with those corresponding to the function of which the vibrations of the induction current are the derivate; that is to say, they agree in type with the primitive vibrations of whatever form. Hence in the receiving telephone of Edison consonantal sounds which depart widely from the purely harmonic type are better rendered than in a telephone which like that of Bell both retards the vibrations in phase and alters them in type.

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5. *The Pseudophone.* *By* Professor Silvanus P. Thompson, *B.A., D.Sc.*

The *pseudophone* is an instrument whose object is to illustrate the laws of the acoustic perception of space by the illusions it produces, just as the pseudoscope of Wheatstone illustrates the laws of the optical perception of space by the ocular illusions it produces.

The pseudophone consists of certain adjustable reflectors which can be attached to the head, and which perform the functions of the natural pinnæ in ordinary hearing. According to Steinhauser's theory of Binaural Hearing, the acoustic perception of space depends upon the relative intensity with which a sound-wave is received into the two ears, this again depending on the conformation and position of the head. Though in general true for many sounds, this theory fails to account for certain observed facts in the perception of sound, and fails in so far as it neglects differences of phase and of pitch.

Experiments made with the pseudophone indicate the direction in which Steinhauser's theory requires modification.

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6. *On the Tension of Vapours near Curved Surfaces of their Liquids.* *By* G. F. Fitzgerald.

The paper is intended to give a physical explanation of the fact that the tension of a vapour in contact with the surface of its liquid when that surface is convex or concave is greater or less respectively than when flat. It rests upon the assumption that evaporation is not merely superficial, but that molecules are emitted from a certain depth beneath the surface of a liquid. From this it follows that the chances of escape of a molecule from a given depth below a convex surface are greater, and from below a concave one less, than from a flat one. Taking the depth

from which emission takes place as very small compared with the radii of curvature of the surface, I have deduced the same formula for the increase or diminution of tension as Sir W. Thomson deduced from capillary phenomena.

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7. *On the Curve of Polarisation Stress, as determined by Mr. Crookes's Measures with the Radiometer.* *By* G. Johnstone Stoney, *M.A., F.R.S., M.R.I.A.*

Mr. Crookes has published in his Bakerian lecture ('Philosophical Transactions,' 1878, pp. 300 and 301) a table and curve representing v, the number of revolutions per minute of a radiometer at different tensions of the residual gas when influenced by a candle three inches off. And at pp. 313 to 316 he gives similar values and the curve for μ, the coefficient of viscosity of the residual gas at low tensions. From these observations we may obtain information with regard to the polarisation stress which caused the motion.

The observations of v were made when the radiometer had attained a constant velocity, from which it follows that the retarding forces then balanced the impelling force, and were therefore a measure of it. Now the retarding forces were three: the friction on the peg, an approximately constant force which may be represented by a; the resistance from viscosity, which may be represented by $b\mu v$ (b being another constant), and the force required to drive the residual air out of the path of the advancing vanes, which may be represented approximately by $c\mathrm{P}v^2$, c being another constant and P the tension. Hence the polarisation stress

$$= a + b\mu v + c\mathrm{P}v^2,$$

the second and third terms of which can be deduced from Mr. Crookes's curves, and separately plotted down. μv will then furnish a curve resembling Mr. Crookes's curve of velocity in its general shape, but with its maximum at a higher tension. $\mathrm{P}v^2$ gives a somewhat similar curve, also with a maximum at a higher tension than Mr. Crookes's curve. The friction of the peg will obviously furnish a horizontal line. We do not know the coefficients a, b, and c, but can perceive that the curve representing the impelling force, *i.e.*, the polarisation stress (whose ordinates will be the sum of the ordinates of the foregoing curves, multiplied respectively by the coefficients a, b, c), must have a form somewhat resembling Mr. Crookes's velocity curve, the chief difference to be noted being that the maximum stress occurs at a higher tension than the maximum velocity.

The form of the curve thus deduced from the observations is in harmony with the approximate curve which results from the theory of polarisation stress put forward by the author of the present communication (see 'Scientific Transactions of the Royal Society of Dublin,' New Series, vol. i.; or 'Philosophical Magazine,' for December, 1878). It is also consistent with the complete expansions for the polarisation stress given in the next communication.

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8. *On Complete Expansions for the Conduction of Heat and the Polarisation Stress in Gases.* *By* G. Johnstone Stoney, *M.A., F.R.S., M.R.I.A.*

Clausius obtained for the flow or conduction of heat across a layer of gas, the expression,

$$\mathrm{G} = \tfrac{1}{4}\beta mn \int_{-1}^{+1} \mathrm{I}\overline{\mathrm{V}}^3\mu \, d\mu,$$

and by the extension of Clausius's investigation, which Mr. George F. Fitzgerald suggested in a letter to 'Nature', the present author obtained for the accompanying polarisation stress, the expression,

$$\mathrm{K} = \tfrac{1}{4}mn \int_{-}^{+1} \mathrm{I}\overline{\mathrm{V}}^2(3\mu^2 - 1)d\mu.$$

These expressions cannot be integrated, since we are ignorant of the laws according to which $\overline{V}^3$, $\overline{V}^2$, and I are distributed round the origin. But the *form* of the series which will express them can be obtained on the hypotheses that the gas is perfect, and that G and K are capable of being expanded in integer powers of $\frac{dT}{dx}$. The expressions which result are

$$\frac{\sqrt{\sigma M}.G}{P\sqrt{T}} = AU + BU^3 + \&c. \quad . \quad . \quad . \quad . \quad (1)$$

$$\frac{K}{P} = A'U^2 + B'U^4 + \&c. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$\frac{K}{P} = A''W^2 + B''W^4 + \&c \quad . \quad . \quad . \quad (3)$$

where U stands for $\frac{P_o e_o}{T_o} \frac{1}{P} \frac{dT}{dx}$, and W stands for $\frac{\sqrt{\sigma M}.G}{P\sqrt{T}}$, the coefficients A, B, &c., being numerical quantities, the same in all 'perfect' gases, which remain to be determined by experiment. In these equations G is the flow of heat, K the polarisation stress, P the tension of the residual gas, T its temperature, $\frac{dT}{dx}$ the rate at which the temperature decreases across the layer, T_o and P_o standard temperature and pressure, e_o the mean free path of the molecules at standard temperature and pressure, σ the specific gravity of the gas compared with a standard gas (say hydrogen), and M a standard mass (say one gramme).

The method by which the foregoing expansions were obtained is believed to be new. The expressions for G and K must be compatible with any change in the gas which is consistent with its continuing a 'perfect' gas. Accordingly a succession of such changes was conceived as happening, and the forms under which P, σ, T, e, must enter were thereby successively determined, the final determination being made by the condition of homogeneity.

The first term of expansion (1) is the approximate expression which Clausius found for the flow of heat; and the first term of expansion (3) is the approximate expression which the author of the present communication found for the polarisation stress. Acccordingly the approximate expressions which had before been known prove to be the first terms of the complete expansions.

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9. *On the Action of Magnets on Liquid Jets.*

By Professor Silvanus P. Thompson, *B.A., D.Sc.*

In studying the phenomena of the voltaic arc, the author has been led to inquire into the actions produced by magnets upon movable conductors, such as jointed wires, flexible metallic leaves, liquid conductors, gases in high rarefaction, flames, and liquid jets, traversed by currents.

Nearly all the phenomena of rotations and translations due to electrodynamic and electromagnetic attraction or repulsion have been demonstrated to hold good for liquid conductors, both those which possess metallic conductivity and those which possess only electrolytic conductivity. Davy, Casselmann, and Walker have shown the electric arc to behave as a mobile conductor. Plücker and De la Rive, and more recently Crookes, have observed the existence of these electro-dynamic actions on the luminous discharges in highly rarefied media, and which appear to be electric convection currents rather than electric currents proper.

The author has examined the case of liquid veins, both of dilute acid and of mercury traversed by currents, and finds that these, when subjected to the action of powerful magnets, exhibit analogous motions of translation, rotation, &c. Thus a liquid vein carrying a current between the poles of a horizontal horseshoe electromagnet no longer falls straight but is thrust aside and falls down an inverted curve. A vein falling in front of the pole of a vertical magnet is likewise drawn aside,

tending to become parallel to the hypothetical Ampèrian currents, and to rotate in an opposed sense around the pole. Further, a liquid vein carrying a current falling upon the pointed pole of a vertical magnet is twisted, the sense of the torsion depending on the direction of the current and the polarity of the magnet. The author has also essayed to extend his observations to the case of liquid jets which break in the air, and which, therefore, cannot carry electric currents proper, but only electric convection currents, and the results obtained, though not yet completed, dispose him to include in this set of phenomena the so-called diamagnetism of flames and of jets of smoke and steam.

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10. *On a Hypothesis concerning the Ether in connection with Maxwell's Theory of Electricity.* *By* Dr. O. J. Lodge.

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11. *On a New Electrometer Key.*[1] Dr. O. J. Lodge.

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12. *On Improvements in Dynamo-Electric Machines.* *By* W. Ladd, *F.R.A.S.*

My object in this communication is to describe in a few words the peculiarities and improvements in the construction of Weston's dynamo-electric machine.

The field magnets are composed of iron plates placed side by side in a mould, but separated a uniform distance from each other. The iron magnets on which the wire is to be wound are cast on to 'lugs' or projections on the ends of the plates. The two cast-iron ends and uniting plates form one magnet. The upper and lower magnets are alike, and when joined together by the perforated vertical supports, the inner curved edges of the field plates embrace about two-thirds of the circle in which the armature is made to revolve. The armature is built up of plates which are somewhat like a cogged-wheel in shape. These are stamped out of sheet iron, and when mounted on the shaft are separated from each other at a uniform distance. The radial projections are then arranged in lines, so that the whole forms a very broad cogged-wheel or cylindrical structure, having longitudinal grooves with transverse spaces at regular distances. The longitudinal grooves are for carrying the wire, and it will be observed from the nature of the structure that the wire lies in channels three sides of which are iron, so that the mutual effect upon each other is increased as much as possible.

The ends of the wires are connected to the field magnets and commutator in much the usual way, the currents travelling in one direction only. The commutator is fitted on a portion of the shaft which projects beyond the bearings; this admits of its easy removal and a new one being replaced in three minutes.

Another important feature in the construction is the arrangement for ventilation. The separation between the pole plates of the field magnets, the perforations in the vertical supports of the magnets, and the light framework of the armature, are all for this purpose. The air enters the centre of the armature and is driven out between the layers of wire through the spaces formed by the separated plates of the armature and the field magnets, and thus prevents any part from becoming unduly heated.

Machines of this description are made of various sizes and strengths, and give from one to sixteen lights in single circuit.

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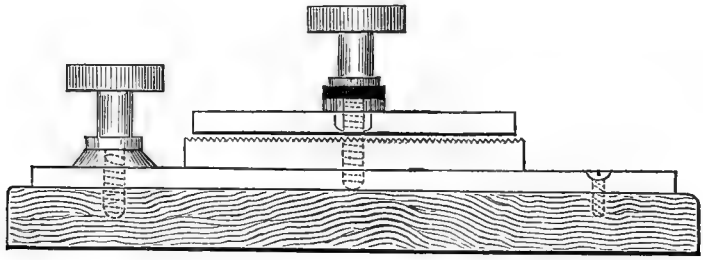
[1] The instrument was exhibited.

13. *On Lightning Protectors for Telegraphic Apparatus.*

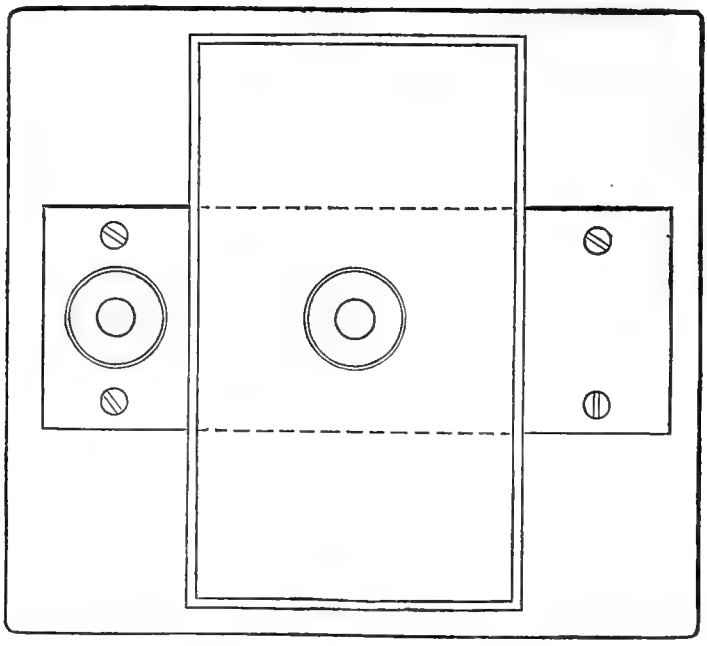
By WILLIAM HENRY PREECE, *Electrician, General Post-Office.*

For many years it was not the practice in England to protect telegraphic apparatus from the injurious effects of atmospheric electricity, because the damage done was so insignificant, and because the remedy was found to be worse than the disease.

But as telegraph systems increased, as the country became enveloped in one vast network of wires, it was found that the damage done became considerable, until, in fact, about 10 per cent. of the apparatus in use was in one year damaged.



Lightning protectors then became essential. Many forms were tried, based on the fact that when a discharge takes place through a non-conductor, such as dry air, at the moment of discharge the resistance along the line of discharge is practically nothing, and therefore all the charge is conducted away. According to



Faraday, 'the ultimate effect is exactly as if a metallic wire had been put into the place of the discharging particles' (*Researches*, Series xii., 1406). Most of those tried failed.

The survival of the fittest has been exemplified in the 'plate' protector. In this form—one of the earliest introduced—one thick plate of brass is in connection with the earth, and another similar plate in connection with the line is placed above it, but separated from it by paper, or by insulating washers. The lightning, entering

the wire, bursts across the paper or air space in preference to passing through the apparatus, and thus escapes to earth.

An important modification of this plate-discharger has been made by Dr. Werner Siemens, who, by serrating or grooving with a pointed tool the opposing faces of the two plates at right angles to each other, converted them into a conductor, which was supposed to be one composed of an infinite number of opposing points. The remarkable action of points in facilitating discharge is well known, and their introduction into lightning protectors occurred very early in the annals of telegraphy, by Mr. C. V. Walker, F.R.S.

Messrs. Siemens' arrangement, very pretty in theory, never carried conviction of its value in the mind of the author, because protectors so prepared never singled themselves out as evidently superior to others that were not so prepared; and while the intersection of the grooves certainly formed mathematical points, they did not form physical or mechanical points, and it is upon the action of this latter kind of point that such remarkable electrical effects are produced.

Dr. Warren De La Rue having very kindly placed his well-known battery of 11,000 cells at the disposal of the writer, he prepared four plate protectors, identical in dimensions, excepting that two were serrated and two were not. The two plates were separated from each other by narrow ebonite washers, ·01 inch thick. The upper plate was placed in connection with the positive pole, and the lower plate with the negative pole. The number of cells was increased until a continuous current of electricity flowed.

1. Plain Plates.

No. of Cells.	Effect Produced.
1,000 . .	Slight sparks just commencing on completing circuit.
1,080 . .	Sparks evident.
1,200 . .	Sparks frequent and abundant.
1,500 . .	Continuous arc.

2. Serrated Plates.

No. of Cells.	Effect Produced.
1,000 . .	Sparks just commencing on making contact.
1,080 . .	Sparks evident.
1,200 . .	Sparks frequent.
1,500 . .	Continuous arc, but fitful.

2,000 cells in each produced a continuous stream of electricity. The effect with 1,500 cells was decidedly more marked with the plain plates than with those serrated. The experiments were extremely pretty, and very decided in their character.

Hence it appears that grooving is not only of no use, but that it rather deteriorates the value of the protector.

These experiments confirm very decidedly the accuracy of the figures obtained by Dr. Warren De La Rue and Mr. Müller on the striking distance between two flat discs given by them in their paper read before the Royal Society (*Phil. Trans.*, vol. 169, 1877), where it was shown that 1,200 cells struck across ·012 inch. Here 1,000 cells struck across ·01 inch, which agrees perfectly with the curve produced by those observers.

It is the practice in the Post-Office Telegraph Department to keep these plates apart by thin paraffined paper, ·002 inch thick, so that the air-space is really much thinner than that experimented upon, and the striking difference of potential only 250 volts.

Messrs. De La Rue and Müller have shown that for points and various kinds of surfaces opposed to each other plain surfaces act the best for potentials less than 1,500 volts, and that points are only efficient for high potentials. Now, as it is doubtful whether atmospheric electricity causes much higher potential in telegraph wires than 1,000 volts, it is clear that plain surfaces are the most effective for protecting apparatus. It is quite certain that such plates, plain and smooth,

separated by an air-space ·002 inch thick, will form very efficient lightning protectors.

The author is very much indebted to Dr. Warren De La Rue for the performance of the experiments in his laboratory.

SATURDAY, AUGUST 23, 1879.

The following Reports and Papers were read:—

1. *Report of the Committee for calculating Tables of the Fundamental Invariants of Algebraic Forms.*—See Reports, p. 66.

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2. *Report of the Committee on Mathematical Tables.*
See Reports, p. 46.

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3. *On some Problems in the Conduction of Electricity.*
By A. J. C. Allen, *B.A., Scholar of Peterhouse.*

The principal object of this paper is to solve the problem of the conduction of electricity in a spherical current sheet, the electricity being introduced and carried off from the sheet at any number of points, called electrodes; and also to do the same for certain finite portions of a spherical sheet, bounded either by current or equipotential lines, the motion being in all cases steady.

The method of doing this is summed up in the following theories:—

Let $v' = \psi(r'\ \theta')$ be the potential at any point $(r'\ \theta')$ of a plane conducting sheet of any conducting isotropic material and any infinitely small thickness, the sheet being bounded by the curve

$$f(r'\ \theta') = C,$$

the boundary being either a current or equipotential line, or partly the one and partly the other, and there being electrodes of strengths $E_1\ E_2$...at points $r'_1\ \theta'_1$, $r'_2\ \theta'_2$...subject only to the condition $\Sigma\ E = 0$: then if we take a portion of a spherical sheet of radius a of the same material and thickness, bounded by the curve

$$f\left(a \tan \frac{\theta}{2}, \phi\right) = C$$

($\theta\ \phi$ being the ordinary polar currents on the sphere), and place electrodes of strengths $E_1\ E_2$...at points $\theta_1\ \phi_1$, $\theta_2\ \phi_2$...where $\phi_1 = \theta'_1$, $a \tan \frac{\theta_1}{2} = r'$, &c., the potential at any point will be $v = \psi\left(a \tan \frac{\theta}{2}, \phi\right)$, the boundary on the sphere being a current or equipotential line, according to the nature of that in the plane.

This theorem is then applied to deducing solutions for a number of finite areas on the sphere. The case of one source and an equal sink on a complete sphere is discussed in detail, and the current and equipotential lines shown to be two systems of small circles.

A similar theorem, though not quite so universal in its application, is shown to hold for a sheet in the shape of a circular cylinder.

The paper concludes with a solution in singly infinite series of the problem of the conduction of electricity in a plane area, bounded by two concentric circles, and also in that bounded by two concentric circles and two radii, meeting at an angle $\frac{u}{n}$ (n integer).

4. *On the Fundamental Principles of the Algebra of Logic.* By Alexander Macfarlane, *M.A., D.Sc., F.R.S.E.*

In a work recently published, entitled 'The Algebra of Logic,' I have investigated anew the foundations of that branch of mathematical analysis which was originated by Boole in his celebrated treatise on 'The Laws of Thought.' In making this inquiry I have studied the contributions to the subject made by Harley, Venn, Jevons, and other philosophers.

The difficulty and apparent irrationality of Boole's calculus is due to the fact that it is founded on the old and inadequate theory of the operation of the mind in reasoning about quality. That theory supposes that the mind, in forming a compound conception out of two simple conceptions, necessarily considers the second of these as limited by, and in a measure dependent upon, the first; in the theory which I advance it is maintained that the mind may, on the one hand, form compound conceptions in which the second element is entirely dependent on the first; and, on the other hand, compound conceptions, in which the two elements are mutually independent.

I consider that the fundamental notion in this branch of analysis is that of a collection of homogeneous objects having differentiating characters. The collection of objects, so far forth as they are homogeneous, may be denoted by u (as they form the *universe* considered in the particular investigation); a differentiating character may be denoted by a small letter, as x. The symbol x applies to, and is entirely dependent upon, u. The arithmetical value of u is the number of the objects considered, and may be singular, plural, or infinitely great. The arithmetical value of x is the ratio of the number of the objects which have the character x to the whole number of objects considered.

By $x=y$ it is asserted that those of the objects which have the character x are identical with those which have the character y. Hence the members of a logical equation are also equal arithmetically, and have the same sign. When the characters equated are identical, the equation is an identity; when they are merely equivalent, the equation is one of condition.

The symbol $+1$ denotes that mental operation which, when applied to ux, takes them once and arranges them in the positive direction along the line in which the mind moves in counting; and -1 arranges them along the negative direction. These operations are connected by the relations $+1-1=0$. The symbols $(-1)^{\frac{1}{2}}$ and $(-1)^{\frac{3}{2}}$ that is, $(-)^{\frac{1}{2}}$, and $(-)^{\frac{3}{2}}$, when applied to ux, arrange them along another and independent line of counting in the positive and negative directions respectively.

In $x+y$ the two parts are perfectly independent, and therefore are not necessarily mutually exclusive. In the expression $x-y$, the two parts destroy one another as far as possible in virtue of the relation $+1-1=0$; the result in general consists of a positive part and a negative part.

Thus a qualitative expression x is in general both positive and negative. When it is positive and not negative, it satisfies the condition $x^2=x$; when negative and not positive, it satisfies the condition $x^2=-x$; and when neither positive nor negative, it satisfies the two conditions $x^2=x$ and $x^2=-x$.

uxy properly denotes those of the objects which have the character x and which have the character y. The expression xy is a function of x and y, in which these symbols are co-ordinately dependent on u. According to Boole, x applies to u, and y applies to ux. But y applied to ux has in general a different meaning and a different arithmetical value from y applied to u; hence it is necessary to denote the change of subject by a mark, as $x.y$. This distinction appears in the theory of probability, in the contrast between two events which are independent of one another, and two events which are dependent one on the other.

The function xy has a single meaning and arithmetical value. The function $\frac{x}{y}$, on the contrary, has a manifold meaning and arithmetical value. It means any

expression which, when multiplied by y, is equivalent to x. The manifoldness of the arithmetical value of $\frac{x}{y}$ follows from the circumstance that in $zy=x$ the y is co-ordinate with, not subordinate to the z.

The expression x^m denotes the selective operation resulting from m of the x operations being applied together; and similarly $x^{\frac{1}{m}}$ denotes that selective operation which is such that when m of it are taken simultaneously the result is identical with x.

The rule of signs follows from the relation connecting + and −, viz., $+1-1=0$; taken together with the restriction of + to denote no change of direction by defining $+^2=+$.

Since an expression is in general both positive and negative, an equation in general involves two component equations, the one of which refers to the positive part and the other to the negative part. Hence an inequation requires in general two signs. Thus $a-b \gtrless x-y$ asserts that the positive part of $a-b$ includes the positive part of $x-y$, and that the negative part of $a-b$ is included in the negative part of $x-y$. The ordinary axioms concerning the transformation of equations and inequations still hold true.

It follows from these principles that there is an Algebra of Quality which absorbs the ordinary theories of necessity and probability, and that this Algebra is a generalised form of the ordinary Algebra. Hence all the theorems about quantity are, after being properly generalised, true of quality also; and conversely, all the novel theorems about quality are, after being restricted by a particular condition, true of quantity.

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5. *Note on a Theorem in Linear Differential Equations.*

By W. H. L. Russell, *F.R.S.*

The author after calling attention to the circumstance that a linear differential equation of the second order is immediately integrable, if the coefficient of the last term taken negatively is equal to the sum of the two first terms, gave the following theorem:—

Let $\mathrm{H}\frac{d^4u}{dx^4}+\mathrm{K}\frac{d^3u}{dx^3}+\mathrm{L}\frac{d^2u}{dx^2}+\mathrm{M}\frac{du}{dx}+\mathrm{N}=0$, be a linear differential of the fourth order, where H, K &c. are rational functions of x, then if $z=\lambda\frac{d^2u}{dx^2}+\mu\frac{du}{dx}+\nu u$, the proposed equation may be reduced to linear differential equation of the second order in z, if

$$\mathrm{N}^4\rho^8-2\mathrm{LN}^3\rho^7+(\mathrm{L}^2\mathrm{N}^2+\mathrm{KMN}^2)\rho^6+(2\mathrm{HLN}^2-\mathrm{KLMN}-\mathrm{K}^2\mathrm{N}^2-\mathrm{HM}^2\mathrm{N})\rho^5$$
$$-(2\mathrm{H}^2\mathrm{N}^2+2\mathrm{HL}^2\mathrm{N}-2\mathrm{HKMN}-\mathrm{K}^2\mathrm{LN}-\mathrm{HM}^2\mathrm{L})\rho^4$$
$$+(2\mathrm{H}^2\mathrm{LN}-\mathrm{HKLM}-\mathrm{H}^2\mathrm{M}^2-\mathrm{HK}^2\mathrm{N})\rho^3+(\mathrm{H}^2\mathrm{L}+\mathrm{H}^2\mathrm{KM})\rho^2-2\mathrm{H}^3\mathrm{L}\rho+\mathrm{H}^4=0,$$

where ρ is any constant.

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6. *On the Repulsion of Wires influenced by Electric Currents.*

By W. H. L. Russell, *F.R.S.*

The object of this paper was to ascertain the possibility of a certain experiment for ascertaining the repulsion of two voltaic wires influenced by currents moving in them in opposite directions.

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7. *On Plane Class-Cubics with three Single Foci.*

By Henry M. Jeffery, *M.A.*

1. These cubics may be studied in three divisions, as the triangle ABC formed by the foci as angular points is equilateral, isosceles, or scalene. The cases have been

already published, in which one or more foci are at an infinite distance, or two or three foci unite to form a multiple focus.[1]

2. The locus of the satellite-point, when there are inflexional cubics in a family of confocal groups, is material to the classification: it is obtained by eliminating the parameter from the quartic and sextic invariants of the cubic equation to a group. According to the position of the satellite-point on or within the several convolutions of this locus, a confocal group may contain an odd or even number of critical values; if the satellite is on the locus, there is one inflexional cubic, and there may be three or one other critical values; and if it do not lie on the locus, there is an even number, four, two, or none. If a focus be at infinity, there is one additional critical cubic. If the satellite lie on a side of ABC, there is a loss of a critical value. There are at the most six critical values.

3. The envelope of the stationary tangents of the inflexional cubics in a family of groups of confocal cubics is a class-quartic.

4. Let there be inflexional cubics in a family of groups of class-cubics, thus denoted:

$$2\kappa\, abc\, pqr + (axp + byq + czr)\Sigma(a^2p^2 - 2bcqr\cos A) = o;$$

the locus of the satellite (x, y, z) is found, by equating the invariants to zero. For brevity $l, m\, n$, denote cos A, cos B, cos C.

$$\begin{aligned}
S \equiv &-\left\{\left[\kappa - (la + m\beta + n\gamma)\right]^2 - \left[a^2 + \beta^2 + \gamma^2 + (2l + 4mn)\beta\gamma + \ \ldots\ .\right]\right\}^2 \\
&- 12\kappa^2(l\beta\gamma + m\gamma a + na\beta) \\
&+ 12\kappa\left\{a\beta\gamma(1 + l^2 + m^2 + n^2 + 4lmn) + a(\beta^2 + \gamma^2)(l + mn) + \ \ldots\ .\right\} = o.
\end{aligned}$$

$$\begin{aligned}
T \equiv &-8\left\{(\kappa - \Sigma la)^2 - \Sigma\left[a^2 + (2l + 4mn)\beta\gamma\right]\right\}^3 \\
&+ 144\left\{(\kappa - \Sigma la)^2 - \Sigma\left[a^2 + (2l + 4mn)\beta\gamma\right]\right\} \\
&\times\left\{-\kappa^2\Sigma l\beta\gamma + \kappa\left[a\beta\gamma(1 + 4lmn + \Sigma l^2) + \Sigma a(\beta^2 + \gamma^2)(l + mn)\right]\right\} \\
&- 864\kappa^3 a\beta\gamma + 432\kappa^2\left\{-(\Sigma l\beta\gamma)^2 + \Sigma\left[\beta^2\gamma^2 + (2l + 4mn)a^2\beta\gamma\right]\right\} = o.
\end{aligned}$$

These forms are equally true for spherical and plane geometry. But if the cubic is plane, S and T may be simplified.

$$S \equiv -\left(\kappa^2 - 2\kappa\Sigma la - \frac{\Delta^2}{R^2}\right)^2 - 12\kappa^2\Sigma l\beta\gamma + 6\kappa\frac{\Delta}{R^2}\Sigma a\beta\gamma = o$$

$$\begin{aligned}
T \equiv &-8\left(\kappa^2 - 2\kappa\Sigma la - \frac{\Delta^2}{R^2}\right)^3 \\
&- 144\left(\kappa^2 - 2\kappa\Sigma la - \frac{\Delta^2}{R^2}\right)\left(\kappa^2\Sigma l\beta\gamma - \frac{\kappa\Delta}{2R^2}\Sigma a\beta\gamma\right) \\
&- 864\kappa^3 a\beta\gamma + 108\frac{\kappa^2}{R^2}(\Sigma a\beta\gamma)^2 = o.
\end{aligned}$$

The eliminant of κ is the locus of the satellite-point. This would not be useful to calculate; but the asymptotes, the intersections by the sides of ABC, and by parallels to those sides, and intersections by the circle circumscribed about ABC ($\Sigma a\beta\gamma = o$) can be obtained in serviceable forms, as well as the form of the curve at the vertices of ABC.

[1] See Reports of British Association, and the *Quarterly Journal of Mathematics* for 1876-8, in which last-named periodical the present memoir will be published *in extenso*.

5. These equations may be presented in a simpler form. Let P, Q, R, denote the several functions $\kappa^2 - 2\kappa\Sigma la - \frac{\Delta^2}{R^2}$, $\kappa\Sigma l\beta\gamma - \frac{\Delta}{2R^2}\Sigma\beta\gamma a$, $2\kappa a\beta\gamma - \frac{1}{4R^2}(\Sigma\beta\gamma a)^2$.

The invariants of § 4 may be written:

$$P^2 + 12\kappa Q = o. \qquad P^3 + 18\kappa PQ + 54\kappa^2 R = o.$$

These may be combined to form two cubics in κ:

$$PQ + 9\kappa R = o \ . \ . \ . \ (1) \quad 3PR = 4Q^2 \ . \ . \ . \ (2).$$

If we neglect $\frac{\Delta}{R}$ and its powers, the direction of the asymptotes can be obtained by the resultant of two quadratics in κ, and if the first power of $\frac{\Delta}{R}$ be also retained, the position of the asymptotes may also depend on the solution of two quadratics.

They are found to be eight in number, but only six real. Two more asymptotes would appear to be given by the factor $\Sigma\beta\gamma$, which occurs in the eliminant. But this factor is irrelevant, since $Q = o$, $R = o$ satisfy the equations (1), (2), so that $4a\beta\gamma\Delta - \Sigma\beta\gamma \sin A$. $\Sigma l\beta\gamma$ is a factor of the resultant, and should be omitted.

6. Let the three foci of the cubic constitute the vertices of an equilateral triangle.

A group of confocal cubics is thus denoted:

$$2\kappa pqr + (xp + yq + zr)(p^2 + q^2 + r^2 - qr - pr - pq) = o.$$
$$S \equiv (\kappa^2 - 2\kappa\Delta - 3\Delta^2)^2 + 6\kappa(\kappa - 3\Delta)\Sigma\beta\gamma = o,$$

if each side of ABC be the unit of length.

It is remarkable that $\kappa - 3\Delta$ measures S, so that

$$6\Delta pqr + (xp + yq + zr)(p^2 + q^2 + r^2 - qr - pr - pq) = o,$$

denotes an equiharmonic cubic, whatever be the position of the satellite. We can examine its properties apart. Thus the Hessian of this family is the same complex, wherever the satellite is placed, viz., the centre of ABC, and the line at infinity. The species of equiharmonic is thus determined: for the Hessian of the other species consists of three real points.

Its Cayleyan is also independent of the satellite, and determines the line at infinity and a point-conic at the centre. The evectant of T is also an equiharmonic cubic of the other species, so that the series of equiharmonics may be multiplied indefinitely.

7. The bounding curve, when ABC are the vertices of an equilateral triangle is a complex, one portion forming a tricuspidal bicircular quartic.

(1) It is shown in § 6, that $\kappa - 3\Delta$ measures S. This value substituted in T gives the bicircular quartic

$$(\beta\gamma + \gamma a + a\beta)^2 = 4a\beta\gamma(a + \beta + \gamma)$$

Or,

$$\sqrt{\beta\gamma} + \sqrt{\gamma a} + \sqrt{a\beta} = o.$$

When transformed to line-co-ordinates it exhibits an acubitangential class-cubic

$$p^{\frac{1}{3}} + q^{\frac{1}{3}} + r^{\frac{1}{3}} = o,$$

whose bitangent is the line at infinity.

(2) The second factor of S is

$$\kappa^3 - \kappa^2\Delta - \kappa(5\Delta^2 - 6\Sigma\beta\gamma) - 3\Delta^3 = o,$$

When combined with T

$$4\kappa^2\Sigma\beta\gamma + \kappa(36a\beta\gamma - 8\Delta\Sigma\beta\gamma) + \tfrac{9}{2}(\Sigma\beta\gamma)^2 - 12\Delta^2\Sigma\beta\gamma = o.$$

Their eliminant is the locus of the satellite, when the confocal family contains inflexional cubics. The direction of the asymptotes may be obtained by neglecting Δ and its powers in these two equations, and their actual position, by retaining the first power of Δ only.

8. The group, in which the satellite is the centre of ABC, has been studied in

point-co-ordinates by Professor Cayley, 'On Cubic Cones and Curves' (*Cambridge Phil. Trans.* 1856). If we write the parameter

$$(6l+3)pqr+(p+q+r)(p^2+q^2+r^2-qr-pr-pq)=o.$$

this assumes the canonical form

$$p^3+q^3+r^3+6lpqr=o.$$

The whole series of non-singular forms may be exhibited at once by line co-ordinates. For order-cubics diagrams are most conveniently drawn by the equivalent equation referred to the cusps (or inflexional points, dually viewed), and the points in which the tangents at the cusps concur:

$$(\mathrm{P}+\mathrm{Q}+\mathrm{R})^3+6\kappa\mathrm{PQR}=o.$$

where $\mathrm{P}=-2lp+q+r : \mathrm{Q}=p-2lq+r : \mathrm{R}=p+q-2lr.$

$$\kappa=\frac{4(l-1)^3}{1-2l+4l^2}$$

The dual order-cubics are the two redundant hyperbolæ, with three diameters, simplex trilateral (Newton's Fig. 33) and simplex quadrilateral (Fig. 34). The equiharmonic form, in which the stationary tangents or asymptotes concur, is drawn (Fig. 42). The complex or bipartite form, in which an oval is enclosed by the asymptotic triangle is not considered by Newton, but by his commentator, Stirling.

In one case the form of conversion fails, when

$$\kappa=-\tfrac{9}{2},\ (\mathrm{P}+\mathrm{Q}+\mathrm{R})^3-27\ \mathrm{PQR}=o,\ \text{or}\ \mathrm{P}^{\frac{1}{3}}+\mathrm{Q}^{\frac{1}{3}}+\mathrm{R}^{\frac{1}{3}}=o.$$

This represents part of the bounding curve when ABC is equilateral (*supra*, § 7). But it is not represented in the canonical form, by the value $l=-\frac{1}{2}$, except that the line at infinity is common to both forms. Especial interest attaches itself to this fault, since *in plano* there is thus occasioned a loss of one critical value, as compared with spherics, which loss first occurring when the satellite is at the centre of ABC, and therefore when it is within the bounding curve $(\mathrm{P}^{\frac{1}{3}}+\mathrm{Q}^{\frac{1}{3}}+\mathrm{R}^{\frac{1}{3}})$, continues throughout the various positions of the satellite.

It may be noticed that the two harmonic curves of this group are conjugate, *i.e.*, each is the Hessian of the other. Hence it becomes apparent why the invariant $(\mathrm{T}=o)$ expresses the condition that the second Hessian shall be the original curve. This relation holds good also when the parameters are imaginary.

9. If three foci of a class-cubic be in any finite position, the envelope of the stationary tangents of the inflexional cubics in a family of such confocal groups is a class-quartic.

If such a group be denoted—

$$\mathrm{U}\equiv\frac{pqr}{ap\mathrm{P}+bq\mathrm{Q}+cr\mathrm{R}}+\lambda p+\mu q+\nu r=o.$$

where $\mathrm{P}=ap-bq$ as $\mathrm{C}-cr\cos\mathrm{B}$, and Q, R have similar values, so that

$$ap\mathrm{P}+bq\mathrm{Q}+cr\mathrm{R}=\Sigma\ (a^2p^2-2bcqr\cos\mathrm{A})=4\Delta^2.$$

One condition for a point of inflexion is

$$\frac{d^2\mathrm{U}}{dp^2}\cdot\frac{d^2\mathrm{U}}{dq^2}-\left(\frac{d^2\mathrm{U}}{dpdq}\right)^2=o.$$

This determines the envelope:

$$(ap+bq+cr)\ (-ap+bq+cr)\ (ap-bq+cr)\ (ap+bq-cr)$$
$$=8abc\,pqr\ (ap\cos\mathrm{A}+bq\cos\mathrm{B}+cr\cos\mathrm{C}).$$

Lines which join the centres of the inscribed and escribed circles with the foci and the centre of the circumscribed circle, touch the envelope.

This is the analogue of Plücker's theorem: the locus of the cusps in a family of groups of redundant hyperbolæ is the maximum ellipse, which can be inscribed in the triangle formed by the asymptotes.

If the triangle formed by the foci is equilateral, the class-quartic degenerates

into the complex formed by the centre of the triangle and an equiharmonic cubic, whose cusps are at infinity,

$$(-p+q+r)\ (p-q+r)\ (p+q-r)=4pqr.$$

10. Diagrams were exhibited of the bounding curves, or loci of the satellites of the foci in groups of confocal cubics, when the foci stand at the angles of equilateral, isosceles, and scalene triangles, both acute-angled and obtuse-angled. Complete sets of critical bitangential and inflexional cubics, with their companion curves, were also exhibited, to illustrate every possible variety of class-cubic in each family of groups.

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8. *On a Modification of the Law of Facility.*

By DONALD M'ALISTER, *B.A., B.Sc.*

Suppose we prepare a series of tints of grey, composed of varying proportions of black and white, and arrange them in regular gradation of depth so that to the eye the successive terms of the series differ by equal amounts. Then experiment and observation, summed up in the Law of Fechner, show us that the series of numbers which express the percentages of black (or of white) in the successive tints form a geometrical series. If now a person tried to match a grey tint which he had seen, he would be liable to error. By the ordinary principle, in any large number of such fallible matches, we deem equal departures from the truth to be equally probable, and take the mean of all the estimates as the best value of the *true* tint which we can derive from them. But the previous considerations show us that the 'mean' must be not the *arithmetic mean*, but the *geometric mean*. For example, tints containing 4, 8, 16, parts of black will seem equally graded. It is as likely, therefore, that, the true tint being 8, an estimate 16 shall be made as an estimate 4. We should make a mistake if, having only these two estimates before us, we inferred that the AM. or 10 was most probably the truth, and not the GM. or 8.

This particular example is the type of a large number of cases connected with fallible *estimates*, and of many statistical series where there is reason to believe that a 'geometric mean' gives a truer average or representative than the ordinary arithmetic mean. It becomes of importance to inquire what modification must be made in the Law of Facility. This law purports to represent the distribution of aberrant measures round the mean. And it is well known that the assumption that the AM. is the most probable value leads to the expression of the Theory of Errors, viz., $y = \epsilon^{-h^2x-a^2}$, x being the measure and a the mean. What law follows from the assumption that the GM. is the most probable mean? This is the gist of the reasoning and the problem which Mr. Francis Galton laid before me some time since. I propose here merely to state my answer, leaving the proofs and the development of the theory to another occasion.

If x (as before) be the measure, a the geometric mean, the (infinitesimal) probability that x is the estimate made is proportional to

$$\exp\left(-h^2\left(\log\frac{x}{a}\right)^2\right),$$

where '*exp*' is brief for '*ϵ to the power of*.'

If the question be modified, as suggested by the ordinary theory, and it be asked 'What is the probability of an estimate lying between the close limits x and $x+\delta x$?' The answer is—

$$\frac{h}{\sqrt{\pi}}\exp\left(-h^2\left(\log_e\frac{x}{a}\right)^2\right)\frac{\delta x}{x}.$$

In both cases h is a constant depending on the general closeness of the measures which, as in the ordinary theory, we may call the 'measure of precision' or '*weight*.'

The matter has statistical and physiological bearings of great interest, and I believe of some practical value.

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9. *Note on the Enumerations of Primes of the Forms* $4n+1$ *and* $4n+3$.

By J. W. L. Glaisher, *M.A., F.R.S.*

At the last meeting of the British Association I communicated the results of an enumeration, then just completed, of the primes of the form $4n+1$ and of the form $4n+3$ in three groups, each of 100,000 numbers, viz., between 0 and 100,000, between 1,000,000 and 1,100,000, and between 2,000,000 and 2,100,000. These results are printed on page 471 of the 'Report' for 1878. It is there stated that 'the numbers given in the table are the result of a duplicate enumeration; but a third enumeration will be required, in order to render it certain that they are absolutely free from error.' This third enumeration has now been made, and the following two errors in the table were detected by means of it: in the first ten thousand of the second million the numbers of $4n+1$ and $4n+3$ primes should be respectively 390 and 363, instead of 391 and 362 as printed, and in the third ten thousand of the third million the numbers should be 350 and 343 instead of 349 and 344 as printed. The totals of the columns thus become 3,642 and 3,574 in the second million, and 3,463 and 3,411 in the third million.

Since the meeting at Dublin the enumerations have also been made for the first hundred thousand numbers of the fourth, seventh, eighth, and ninth millions. In the case of the fourth million the enumerations were made from the proof sheets of my father's factor table for this million, which is now stereotyped and ready for publication.

The total numbers for primes of the forms $4n+1$ and $4n+3$ in the first one hundred thousand numbers of each of the seven millions are—

	Number of $4n+1$ primes	Number of $4n+3$ primes	Difference	Total number of primes
0— 100,000	4,784	4,808	−24	9,592
1,000,000—1,100,000	3,642	3,574	+68	7,216
2,000,000—2,100,000	3,463	3,411	+52	6,874
3,000,000—3,100,000	3,368	3,308	+60	6,676
6,000,000—6,100,000	3,193	3,204	−11	6,397
7,000,000—7,100,000	3,182	3,187	− 5	6,369
8,000,000—8,100,000	3,126	3,124	+ 2	6,250

The results for the whole seven groups are—

Number of $4n+1$ primes	Number of $4n+3$ primes	Difference	Total number of primes
24,758	24,616	142	49,374

It should be stated that 1 was counted as a prime of the form $4n+1$; 2, of course, was not counted at all.

The details of these enumerations will appear in the 'Proceedings of the Royal Society' (vol. xxix. pp. 192–197).

Professor Tchebycheff, in a letter to M. Fuss, 'sur un nouveau théorème relatif aux nombres premiers contenus dans les formes $4n+1$ et $4n+3$,'[1] states that he has found that the functions which determine the total number of primes of the form $4n+1$ and the total number of those of the form $4n+3$, inferior to a given very large limit x, differ essentially in their second terms; this term being greater in the latter case than in the former, so that for certain values of x the number of $4n+3$ primes exceeds that of $4n+1$ primes by a number approximately equal to $\frac{\sqrt{x}}{\log x}$.

Of course an enumeration of primes in certain groups such as those chosen

[1] 'Bulletin de la Classe Physico-Mathématique de l'Académie Impériale des Sciences de Saint-Pétersbourg,' t. xi. (1853), col. 208.

above is different in character to an enumeration extending from zero to a given high number, but Professor Tchebycheff's result gives a special interest to separate enumerations of $4n+1$ and $4n+3$ primes.

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10. *Formulæ in Elliptic Functions.* *By* J. W. L. Glaisher, *M.A., F.R.S.*

The formulæ in question, which give the products of three dn's or three sn's in terms of the sn, cn, dn's of the four arguments $\frac{1}{2}(a+b+c)$, $\frac{1}{2}(-a+b+c)$, $\frac{1}{2}(a-b+c)$, $\frac{1}{2}(a+b-c)$, are

$$\mathrm{dn}\,a\,\mathrm{dn}\,b\,\mathrm{dn}\,c=\frac{k'^2+k^2\mathrm{cn}\,s\,\mathrm{cn}(s-a)\,\mathrm{cn}(s-b)\,\mathrm{cn}(s-c)}{1+k^2\mathrm{sn}\,s\,\mathrm{sn}(s-a)\,\mathrm{sn}(s-b)\,\mathrm{sn}(s-c)},$$

$$k^2\mathrm{cn}\,a\,\mathrm{cn}\,b\,\mathrm{cn}\,c=\frac{-k'^2+\mathrm{dn}\,s\,\mathrm{dn}(s-a)\,\mathrm{dn}(s-b)\,\mathrm{dn}(s-c)}{1+k^2\mathrm{sn}\,s\,\mathrm{sn}(s-a)\,\mathrm{sn}(s-b)\,\mathrm{sn}(s-c)},$$

where $s=\frac{1}{2}(a+b+c)$.

Adding the two formulæ, we have

$$\mathrm{dn}\,a\,\mathrm{dn}\,b\,\mathrm{dn}\,c+k^2\mathrm{cn}\,a\,\mathrm{cn}\,b\,\mathrm{cn}\,c=\frac{\mathrm{dn}\,s\,\mathrm{dn}(s-a)\,\mathrm{dn}(s-b)\,\mathrm{dn}(s-c)+k^2\mathrm{cn}\,s\,\mathrm{cn}(s-a)\,\mathrm{cn}(s-b)\,\mathrm{cn}(s-c)}{1+k^2\mathrm{sn}\,s\,\mathrm{sn}(s-a)\,\mathrm{sn}(s-b)\,\mathrm{sn}(s-c)}.$$

As a particular case let

$$a=b=c=2x,$$

and the formulæ become

$$\mathrm{dn}^3 2x=\frac{k'^2+k^2\mathrm{cn}3x\,\mathrm{cn}^3x}{1+k^2\mathrm{sn}3x\,\mathrm{sn}^3x},$$

$$k^2\mathrm{cn}^3 2x=\frac{-k'^2+\mathrm{dn}3x\,\mathrm{dn}^3x}{1+k^2\mathrm{sn}3x\,\sin^3x},$$

$$\mathrm{dn}^3 2x+k^2\mathrm{cn}^3 2x=\frac{\mathrm{dn}3x\,\mathrm{dn}^3x+k^2\mathrm{cn}3\,x\mathrm{cn}^3x}{1+k^2\mathrm{sn}3x\,\sin^3x};$$

and to these may be added

$$k'^2=\frac{\mathrm{dn}3x\,\mathrm{dn}^3x-k^2\mathrm{cn}3x\,\mathrm{cn}^3x}{1+k^2\mathrm{sn}3x\,\mathrm{sn}^3x}$$

The paper in which the above formulæ occur will be communicated to the Cambridge Philosophical Society.

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11. *Summation of a class of Trigonometrical series.*
By J. W. L. Glaisher, *M.A., F.R.S.*

We have

$$1+x^n=1-wx\,.\,1-w^3x\,\ldots\,1-w^{2n-1}x$$

$$\text{where } w=\cos\frac{\pi}{n}+i\sin\frac{\pi}{n},$$

whence

$$1+x^{2n}=1-(\zeta x)^2\,.\,1-(\zeta^3x)^2\,\ldots\,1-(\zeta^{2n-1}x)^2$$

$$\text{where } \zeta=\cos\frac{\pi}{2n}+i\sin\frac{\pi}{2n};$$

Replacing x by $x\left(\cos\frac{\pi}{4n}-i\sin\frac{\pi}{4n}\right)$, this becomes

$$1-ix^{2n}=1-(\rho x)^2\,.\,1-(\rho^5x)^2\,\ldots\,1-(\rho^{4n-3}x)^2$$

$$\text{where } \rho=\cos\frac{\pi}{4n}+i\sin\frac{\pi}{4n}.$$

Now

$$\frac{\sin(a-x)\sin(a+x)}{\sin^2 a} = \left\{1-\frac{x^2}{a^2}\right\}\left\{1-\frac{x^2}{(a-\pi)^2}\right\}\left\{1-\frac{x^2}{(a+\pi)^2}\right\}\left\{1-\frac{x^2}{(a-2\pi)^2}\right\}\left\{1-\frac{x^2}{(a+2\pi)^2}\right\}\cdots$$

so that if

$$\frac{\sin(a-\rho x)\sin(a+\rho x)}{\sin^2 a}$$

be denoted by $\phi(\rho)$, then

$$\phi(\rho)\cdot\phi(\rho^5)\cdots\phi(\rho^{4n-3}) = \left\{1-i\frac{x^{2n}}{a^{2n}}\right\}\left\{1-i\frac{x^{2n}}{(a-\pi)^{2n}}\right\}\left\{1-i\frac{x^{2n}}{(a+\pi)^{2n}}\right\}\cdots (1)$$

Also

$$\frac{\sin(a-\rho x)\sin(a+\rho x)}{\sin^2 a} = \tfrac{1}{2}\frac{\cos 2\rho x-\cos 2a}{\sin^2 a}$$

and therefore

$$\phi(\mathrm{A}+i\,\mathrm{B}) = \tfrac{1}{2}\frac{\cos 2\mathrm{A}x\cosh 2\mathrm{B}x-\cos 2a-i\sin 2\mathrm{A}x\sinh 2\mathrm{B}x}{\sin^2 a} \quad\ldots\ldots (2)$$

Now if $(a_1+i\beta_1)(a_2+i\beta_2)\ldots = (x_1+iy_1)(x_2+iy_2)\ldots$ (3)

(the number of factors on either side being arbitrary)

then

$$\text{arc tan}\frac{\beta_1}{a_1}+\text{arc tan}\frac{\beta_2}{a_2}+\&\text{c.} = \text{arc tan}\frac{y_1}{x_1}+\text{arc tan}\frac{y_2}{x_2}+\&\text{c.} \quad\ldots\ldots (4)$$

for, changing the sign of i in (3)

$$(a_1-i\beta_1)(a_2-i\beta_2)\ldots = (x_1-iy_1)(x_2-iy_2)\ldots$$

and therefore

$$\Sigma\log\frac{a+i\beta}{a-i\beta} = \Sigma\log\frac{x+iy}{x-iy}$$

which leads at once to (4) in virtue of the formula

$$\text{arc tan}\frac{\mathrm{B}}{\mathrm{A}} = \frac{1}{2i}\log\frac{\mathrm{A}+i\mathrm{B}}{\mathrm{A}-i\mathrm{B}}.$$

Applying this theorem to (1) and (2), we find that

$$\text{arc tan}\frac{x^{2n}}{a^{2n}}+\text{arc tan}\frac{x^{2n}}{(a-\pi)^{2n}}+\text{arc tan}\frac{x^{2n}}{(a+\pi)^{2n}}+\&\text{c.}$$

$$= \Sigma_{s=0}^{sn-=1}\frac{\sin(2\,\mathrm{A}_s x)\sinh(2\,\mathrm{B}_s x)}{\cos(2\,\mathrm{A}_s x)\cosh(2\,\mathrm{B}_s x)-\cos 2a}$$

$$\text{where } \mathrm{A}_s = \cos\left(\frac{4s+1}{4n}\pi\right),\ \mathrm{B}_s = \sin\left(\frac{4s+1}{4n}\pi\right)$$

and this, on replacing x and a by $\frac{\pi x}{b}$ and $\frac{\pi a}{b}$, becomes

$$\text{arc tan}\frac{x^{2n}}{a^{2n}}+\text{arc tan}\frac{x_{2n}}{(a-b)^{2n}}+\text{arc tan}\frac{x^{2n}}{(a+b)^{2n}}+\text{arc tan}\frac{x^{2n}}{(a-2b)^{2n}}$$

$$+\text{arc tan}\frac{x^{2n}}{(a-2b)^{2n}}+\&\text{c.} = \Sigma_{s=0}^{s=n-1}\frac{\sin\left(\frac{2\pi x}{b}\mathrm{A}_s\right)\sinh\left(\frac{2\pi x}{b}\mathrm{B}\right)}{\cos\left(\frac{2\pi x}{b}\mathrm{A}_s\right)\cosh\left(\frac{2\pi x}{b}\mathrm{B}_s\right)-\cos\frac{2\pi a}{b}}.$$

As a particular case, put $a=1$, $b=2$; and this equation gives

$$\arctan\frac{x^{2n}}{1^{2n}}+\arctan\frac{x^{2n}}{3^{2n}}+\arctan\frac{x^{2n}}{5^{2n}}+\&c.$$

$$=\tfrac{1}{2}\sum_{s=0}^{s=n-1}\frac{\sin(\pi x\mathrm{A}_s)\sinh(\pi x\mathrm{B}_s)}{\cos(\pi x\mathrm{A}_s)\cosh(\pi x\mathrm{B}_s)+1}$$

$$=\tfrac{1}{2}\sum_{s=0}^{s=n-1}\frac{\sin(\pi x\mathrm{A}_s)\sinh(\pi x\mathrm{B}_s)}{\cos(\pi x\mathrm{A}_s)\cosh(\pi x\mathrm{B}_s)+1}.$$

It can also be shown by the method employed above that

$$\arctan\frac{x^{2n}}{1^{2n}}+\arctan\frac{x^{2n}}{3^{2n}}+\arctan\frac{x^{2n}}{5^{2n}}+\&c.$$

$$=\sum_{s=0}^{s=n-1}\arctan\left\{\tan(\tfrac{1}{2}\pi x\mathrm{A}_s)\tanh(\tfrac{1}{2}\pi x\mathrm{B}_s)\right\}$$

which is readily connected with the result just written; and that

$$\arctan\frac{x^{2n}}{1^{2n}}+\arctan\frac{x^{2n}}{2^{2n}}+\arctan\frac{x^{2n}}{3^{2n}}+\&c.$$

$$=(-)^{n-1}\tfrac{1}{4}\pi-\sum_{s=0}^{s=n-1}\arctan\frac{\tanh(\pi x\mathrm{B}_s)}{\tan(\pi x\mathrm{A}_s)}$$

Of course the two sides of these equations may differ by any multiple of π.

As particular cases, by putting $n=1$ and 2, we have

$$\arctan\frac{x^2}{1^2}+\arctan\frac{x^2}{3^2}+\arctan\frac{x^2}{5^2}+\&c.=\arctan\left\{\tan\frac{\pi x}{2\sqrt{2}}\tanh\frac{\pi x}{2\sqrt{2}}\right\}$$

$$\arctan\frac{x^2}{1^2}+\arctan\frac{x^2}{2^2}+\arctan\frac{x^2}{3^2}+\&c.=\tfrac{1}{4}\pi-\arctan\frac{\tanh\frac{\pi x}{\sqrt{2}}}{\tan\frac{\pi x}{\sqrt{2}}}$$

$$\arctan\frac{x^4}{1^4}+\arctan\frac{x^4}{3^4}+\arctan\frac{x^4}{5^4}+\&c.$$

$$=\arctan\left\{\tan(\tfrac{1}{2}\pi x\alpha)\tanh(\tfrac{1}{2}\pi x\beta)\right\}-\arctan\left\{\tan(\tfrac{1}{2}\pi x\beta)\tanh(\tfrac{1}{2}\pi x\alpha)\right\}$$

$$\arctan\frac{x^4}{1^4}+\arctan\frac{x^4}{2^4}+\arctan\frac{x^4}{3^4}+\&c.$$

$$=-\tfrac{1}{4}\pi+\arctan\frac{\tanh(\pi x\alpha)}{\tan(\pi x\beta)}-\arctan\frac{\tanh(\pi x\beta)}{\tan(\pi x\alpha)}$$

where $\alpha=\cos\frac{1}{8}\pi$, $\beta=\sin\frac{1}{8}\pi$

formulæ which are given in the *Quarterly Journal of Mathematics*, vol. xv., pp. 151–157. The general formulæ to which this note refers are more fully discussed in a paper which will appear in the *Quarterly Journal*, vol. xvi.[1]

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12. *Note on a Method of checking Calculations.* *By* W. H. Walenn.

The object of this note is to draw attention to the advantages of checking calculations by casting out the elevens in preference to casting out the nines.

By this means, in many cases, the calculation can be checked by an appeal to the question and answer only. Also decimal calculations can be checked in

[1] Addition to a paper 'A Theorem in Trigonometry,' vol. xvi. (No. 64.)

consequence of the remainders used being *unitates*, that is, simply the number of units by which the number to be dealt with is in excess of being exactly divisible by the divisor. This divisor may, in practice, be either 9 or 11.

As an instance, suppose the calculation to be checked is $w = 62{\cdot}32, 2{\cdot}375, 3{\cdot}25, 3{\cdot}75 = 1803{\cdot}871875$. In casting out the nines the symbolisation is $U_9\ w = U_9(4.8.1.6) = 3$. In casting out the nines there is no check upon the number of digits in the number operated upon, neither is there a check upon the place of any particular digit, nor upon the figures themselves, if they be either 9 or 0, or if their sum be 9 or any multiple of 9. In 100 there are 33 fractional unitates to reciprocals.

In casting out the elevens there is a check upon the number of digits, upon the place of any digit, and, for the most part, upon the figures themselves. In 100 there are only 9 fractional unitates to reciprocals. $U_{11}(\frac{1}{1}, \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{5}, \frac{1}{6}, \frac{1}{7}, \frac{1}{8}, \frac{1}{9}, \frac{1}{10}, \frac{1}{11}) = 1, 6, 4, 3, 9, 2, 8, 7, 5, 10, \frac{1}{11}$.

Additions can be dealt with at one operation. Subtractions must have the unitate of the minuend made greater than that of the subtrahend. Decimal multiplications must be without contraction; but divisions may be finished at any predetermined place of decimals, taking into account the remainder. Fractions are treated as if of the form $a.\frac{1}{b}$.

The table of powers of $U_{11}N$ repeats after every ten powers, and is therefore very serviceable for checking tables and formulæ in which the higher powers occur.

An Appendix, containing examples, tables, and illustrations, accompanies the original paper.

MONDAY, AUGUST 25, 1879.

The following Reports and Papers were read:

1. *Report of the Committee on Tidal Observations in the English Channel.*
See Reports, p. 71.

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2. *Report of the Committee on Calculations of Sun-heat Co-efficients.*
See Reports, p. 66.

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3. *Report of the Committee on Luminous Meteors.*
See Reports, p. 76.

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4. *On the Direct Motion of Periodic Comets of Short Period.*
By Professor H. A. Newton.

In the 'American Journal of Science' I published a few months since an article on the origin of comets. I undertook in that article to find out if there is in any facts we know about the comets reason to say whether they must have come to us from outside space, or whether they have been formed out of matter that lay on the outer edge of the disc-shaped nebula which the solar system is supposed to have been condensed from. The comets may be divided into two very distinct classes;

the first, the comets whose orbits are very long—so long that they are usually treated as parabolas; the second, the comets of short period, about twelve or fifteen in number.

I found that the distribution of the inclinations of the orbits of the first group was such as should naturally have resulted from a foreign origin of the comets, and was not such as should be expected on the hypothesis that they came to us from a distant source or sources nearly in the plane of the solar system.

The second group, however, consists of comets having orbits but little inclined to the ecliptic, most of them having angles less than 30°. Two only have retrograde motions, Halley's comet, which has so long a period as almost to belong to the first group, and the comet of the November meteors (1866, i.). This latter is probably identical with one of the two comets which crossed our sky in 1366, one chasing the other along the path of the meteors just after the star shower of that year. Even if 1866, i. be a third fragment, it must be classed amongst the periodic comets.

But with these two exceptions, the periodic comets have such a uniform relation to the plane of the solar system as to compel the belief that there is something peculiar to the group in their origin or history. If these comets came to us at first from the stellar spaces, they have been turned into these short orbits by coming very near to a large planet. Can we explain the nearly uniformly direct motion by supposing such a history for them? We may state the question thus. Suppose an immense number of comets to have passed in all conceivable directions by and near to a large planet in such a way as to have their orbits greatly changed. Some of those resulting orbits would be hyperbolas, in which the comets would travel off into outer space. Others would be ellipses of short period, and part of these would bring the comets near enough to the sun for us to see them. Would a large majority of these last move around the sun in the same general direction as the disturbing planet?

To answer this we have to ask how a comet must pass the planet to have its velocity diminished? For it is only by having its velocity diminished that a comet can be turned from a parabolic orbit into one of short period. Though the general problem of perturbations is very complex, yet there is an exceedingly simple answer to the above question, the simplicity being due to the fact that the problem is one of change of potentials only.

If the comet pass in front of the planet the comet's attraction helps the planet forward and increases the planet's velocity. The energy gained by the planet is lost by the comet, and the comet's periodic time is therefore diminished. But if the comet passes behind the planet their mutual attraction checks the planet's motion, and hence increases the velocity of the comet. The simplicity of this law enables us to reduce the whole problem to elementary algebra and trigonometry.

It has been shown by Laplace that when a comet comes very near to a large planet we may divide the path into two parts. The first is so far from the planet that it is regarded as an orbit about the sun with a small perturbation from the planet. The second part is that near to the planet, where we may treat the relative path as a conic section (hyperbola) about the planet, and then the sun's action is only a small disturbing force.

Suppose now a sphere to be described about the planet, which shall be called the *sphere of action* of the planet, of such size that, without the sphere, the planet's action may be disregarded, and within it the small perturbing force of the sun disregarded. Draw a tangent to that sphere at a point A, and let the plane of the paper be the tangent plane. The planet will be on the perpendicular to the plane of the paper beyond A, and its line of motion will meet the tangent plane in some point as B. In the figure assume B to be in front of the planet. Join A B, and draw A C perpendicular to A B.

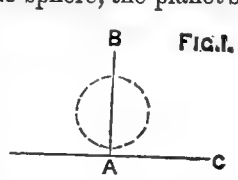


FIG. I.

Further, suppose that an indefinite number of comets approach the planet in a *relative* direction perpendicular to the tangent plane, all having the same velocities. Those passing near to the point A will go down and strike the planet.

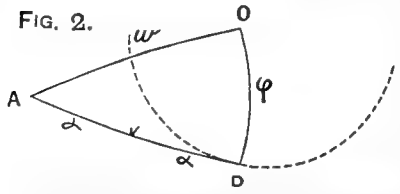
Those passing behind the planet, that is meeting the plane in the figure on the side of the line A C beyond B, will gain velocity and possibly be thrown from elliptic into hyperbolic orbits, along which they would travel off into space.

Those on the other hand which meet the tangent plane in front of the line A C will in general lose velocity and be thrown into orbits having a diminished periodic time. The amount of diminution will depend upon the point in which the comet's path meets the plane A B C, and those comets which suffer a *given* loss will meet the plane in a locus whose equation may be determined.

Using polar co-ordinates, making θ the angle of a radius vector with AB, and p the radius vector, the equation between p and θ is found to be that of a circle.

Let AOD be a spherical triangle about the planet as a centre. Let A be in the relative direction from which a comet comes, O be the apex of the planet's motion, and D the relative direction from which the comet leaves the planets. Then the angle at A is θ and the arc AD is the measure of the angle between the asymptotes of the hyperbolic orbit which the comet describes about the planet (which we call $2a$). Let v be the velocity of the comet in its solar orbit on entering the sphere of action of the planet, v' the same on leaving that sphere, v'' that of the planet in its orbit, and V the relative velocity of comet to planet, which is the same at the two epochs. Let V_0 and p_0 be the relative velocity and the distance of the comet from the planet at the peri-planet. We have then the following equations:—

FIG. 2.



(1) $V_0 p_0 = Vp$, by conservation of areas.

(2) $\tan a + \sec a = \frac{p}{p_0}$, by the property of the hyperbola.

(3) $V^2_0 - V^2 = \frac{\mu}{p_0}$, by the law of potential, μ being constant.

(4) $\left.\begin{aligned} v^2 &= V^2 + v''^2 + 2Vv'' \cos w, \\ v'^2 &= V^2 + v''^2 + 2Vv'' \cos \phi, \end{aligned}\right\}$ by composition of velocities.

(5) $\cos \phi = \cos w \cos 2a + \sin w \sin 2a \cos \theta$, by spherical trigonometry.

Since v, v', and v'' are assumed to be given quantities, we have $\cos \phi$ in terms of $\cos w$ from equations (4), (that is, the comet coming from A must leave the planet in a direction from some point of a small circle described on the spherical surface about O as a centre).

From (1) (2) and (3) we have $2 \tan a = \frac{\mu}{pV^2}$. Substituting this value of a, and the value of $\cos \phi$ from (4) in equation (5), we have the polar equation of a circle between p and θ and constants.

If the comets of short period were thrown into their present orbits by Jupiter, their velocities were diminished in general more than in the ratio $\sqrt{2}$ to 1.

With such a diminution the circle of fig. 1 is imaginary for all values of w less than about 70°, and is very small for all values of w less than 90°. Hence Jupiter can very rarely throw a comet whose motion is at all opposed in direction to his own from a parabolic orbit into one whose period is less than that of the planet. On the contrary, when the comet approaches the planet from behind, the circle rapidly increases in size as w approaches 180°. Hence of the comets which have their orbits thus shortened, by far the largest proportion approach Jupiter from behind. They go around the planet, and though their directions are thereby greatly changed, yet after the change nearly all still follow the planet, that is have a direct motion about the sun.

So far then from the direct motion of the periodic comets being a reason for assigning to them a separate genesis from that of the other comets, that direct motion is just what we ought to expect upon the supposition that the comets have been thrown into their orbits by Jupiter or by other planets.

The two bodies, the comet and the planet, will of course in time, if undisturbed, come back again to the place from which they parted company. The comet will here undergo a new disturbance, perhaps pass close behind the planet and be thrown out into the stellar spaces again.

Some comets will by reason of smaller perturbations have their orbits so changed as to no longer come back to the appointed place of meeting, and these may become more or less permanent members of the solar system.

This conclusion suggests the possibility that the asteroids have also an outside origin. If a comet were to be brought to move in a nearly circular orbit at a distance from the large planets, and it is probably only such an orbit that can be really permanent, then the action of the sun by which the comet's tail is developed ought in the course of time to drive off all the matter that makes the comet's tail and leave the exhausted nucleus to travel in its orbit as a small planet.

If in like manner we can suppose a like origin for some of the satellites, we may be relieved of our difficulty. I cannot conceive how such small bodies can become solid from a gaseous state in the immediate presence of the sun and the large planets.

A possible explanation of the lenticular form of the zodiacal light and its near coincidence with the ecliptic is alike suggested. That body may be matter in very minute parcels which has been thrown into this position by the action of the planet Jupiter.

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5. *On Self-acting Intermittent Siphons and the Conditions which Determine the Commencement of their Action.* *By* ROGERS FIELD, *B.A.*—See Reports, p. 223.

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6. *A short Account of some Experiments made to determine the Friction of Water upon Water at low Velocities. By the Rev.* SAMUEL HAUGHTON, *M.D., D.C.L.*

A spherical ball of granite, unpolished, was suspended by a pianoforte wire, and allowed to hang freely; from the brass collar by which the ball was suspended an index projected on each side, the pointed ends of the indices traversing a graduated horizontal circle, whose centre corresponded with the line of suspension. The suspended ball was immersed in water contained in an iron tub.

The weight of the granite ball was 22452·85 grams, and its mean diameter was 251·46 millimeters. The length of the wire of suspension was 610·8 centimeters, and its diameter was 0·889 millimeter. The diameter of the iron tub was 2 feet 4 inches, and the depth of water contained in it was 1 foot 9 inches.

The method of observation was as follows: the indices of the ball having arrived at the zero of rest, the ball was then displaced by a torsional movement of the wire, and allowed to regain its position of rest by a succession of vibrations, of diminishing amplitudes.

The quantities observed were the time of vibration and the rate of diminution of the amplitude.

The equations of motion of the apparatus are thus found.

$$\frac{d^2x}{dt^2} - X = 0 \qquad (1)$$

where x = the varying amplitude of any point of the surface of the ball measured from its zero of rest.

X = the tangential forces of torsion and friction acting at the point x.

If we assume, that for low velocities the friction will be proportional to the velocity, we shall have

$$X = k^2x - f\frac{dx}{dt} \qquad (2)$$

where k is a coefficient depending on torsion, and f is a coefficient depending on friction.

It is easy to see that the complete integral of the equation of motion

$$\frac{d^2x}{dt^2} + f\frac{dx}{dt} + k^2x = 0 \tag{3}$$

must be of the form

$$x = ae^{mt}\cos nt + be^{mt}\sin nt \tag{4}$$

where a and b are arbitrary constants, and where m and n have the values

$$m = -\frac{f}{2}$$

$$n = \sqrt{k^2 - \frac{f^2}{4}} \tag{5}$$

If we reckon the time from the commencement of the oscillation, equation (4) reduces to

$$x = ae^{mt}\cos nt \tag{6}$$

If T denote the time of a complete double oscillation, we find from the above

$$\theta_n = \theta_o e^{-\frac{fn\mathrm{T}}{2}} \tag{7}$$

where θ_n = amplitude of the $(n + 1)^{th}$ vibration.
θ_o = amplitude of the first vibration.

From (7) we obtain the following working equation for use in the calculations todetermine the coefficient of friction.

$$f = \frac{2}{n\mathrm{T}}\log_e\left(\frac{\theta_o}{\theta}\right) \tag{8}$$

Also we have

$$n = \frac{2\pi}{\mathrm{T}} = \sqrt{k^2 - \frac{f^2}{4}}$$

from which we obtain, after some reductions

$$\mathrm{T} = \frac{4\pi}{\sqrt{4k^2 - f^2}} \tag{9}$$

If we introduce into this equation the value of f determined by (8) we obtain k, which depends on the torsion only.

The mean value of f, the coefficient of friction, in air and water, for amplitudes θ_o ranging up to 360°, was found to be

$$f = \frac{1}{6052{\cdot}7}\ \text{(air)}$$

$$f = \frac{1}{307.27}\ \text{(water)}$$

The details of my experiments will be published by the Royal Irish Academy, and will show that the results are very close to each other, and that the method of observation admits of great precision.

My intention, in commencing the experiments was to ascertain the coefficient of tidal friction, and also to ascertain the elevation of water at the equator or pole, necessary to cause a current; both these results I hope to secure with some approach to accuracy.

7. *On an Instrument for Determining the Sensible Warmth of Air.* *By Professor* G. Forbes, *F.R.S.*

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8. *On Synchronism of Mean Temperature and Rainfall in the Climate of London.* *By* H. Courtenay Fox, *M.R.C.S.*

My object is by the examination of a long series of facts to ascertain whether there be any law which regulates the *occurrence at the same time* of extremes of temperature and rainfall, so far as we can ascertain it in the English climate.

The facts which I have used are the rainfall and mean temperature as for the Royal Observatory in each month and season for 66–67 years. The mean temperature from 1813 to 1840 is that computed by James Glaisher, Esq., F.R.S. (*vide* Philosophical Transactions, 1850, part 7); and from 1841 to the present time it is from direct observation. The rainfall from 1813 to 1840 is derived from sundry observations about London collated by George Dines, Esq., F.M.S., and from 1841 to the present time it also is from direct observation at the Greenwich Observatory.

I have constructed tables *for each month*, in which the sixty-seven (or sixty-six) years are arranged in the order of the mean temperature of that month, beginning with the coldest and ending with the warmest, and also arranged in like manner in the order of their amount of rain. The sixty-seven years are then divided, as nearly as can be, into five equal sections, of which the middle section is termed average years; the division on each side of the average I term cold and warm, dry and rainy, respectively; while the extreme sections I qualify by the word *very*, calling them very cold, very warm, very dry, and very rainy, respectively. We have thus a pretty fair division of the series of years in both these characters. What I have done for each month has been also done on exactly similar principles for each season and for the whole year.

1. *In the winter months, cold tends to be synchronous with dryness, warmth with large rainfall.*—In January so strong is this tendency that the synchronism of cold with dry is without marked exception (that is, there was no instance of a very dry month being also a very warm one).

2. *In the summer months, cold tends to be accompanied by much rain, warmth by dryness.*—The synchronism of warm with dry in July, and that of cold with wet in August, are both without marked exception.

3. To put this in popular language, *rain brings warmth in winter and cold in summer*—that is (if rain be cause, which is by no means proven), it mitigates the special character of each extreme season, winter and summer.

4. But the peculiar laws of summer and winter are found to extend a little over the adjoining months in the following manner. In *November* there are the synchronisms, cold with dry, warm with wet; and both *October* and *March* have a slight tendency to the combination of cold with dryness, although there is in these months indefinite relation between excess of rainfall and temperature. So that there are six months, from October to March, of which four possess strongly the *winter* character of cold with dry, warm with wet, and two have it to the extent of slight cold with dry. On the other hand, the summer synchronism of warmth with dryness obtains in *April* and to a small extent in *May*. The connection between large rainfall and temperature in these months is ambiguous, but upon the whole the balance is in favour of the union of cold with wet. Consequently we have five months, from April to August, the last three of which possess the *summer* character, warm with dry and cold with wet, whilst the first two exhibit the same tendency in a much slighter, though still perceptible, degree. The only definite tendency in *September* is to the synchronism of dry with warm, which so

far as it goes indicates a preference for the æstival rather than for the hyemal character.

5. *Rainy years tend to be either very cold or very warm, whilst years of drought tend to assume an average temperature.*—The dry year is not (as we might expect if the summer synchronism prevailed) a very warm one, nor is it a very cold year (as would be the case if the winter tendency preponderated), but the two tendencies seem in each instance to balance one another. On the other hand, if the year be wet, either it will be also cold, as if it were the law of summer that chiefly affected it, or it will be warm, as though the temperature depended principally upon the winter synchronism.

So far as my reading has extended, I am not aware that these striking laws have been made public before. It would be an interesting subject for further inquiry to ascertain if they prevail for other parts of the globe, or whether they are peculiar to our insular position.

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9. *Experiments on the Influence of the Angle of the Lip of Rain Gauges on the Quantity of Water Collected.* By Baldwin Latham, *C.E., M. Inst. C.E., F.G.S., F.M.S., &c.*

The author having observed that, in the ordinary pattern of the Glaisher gauge, in high winds the rain was often driven up the sloping lip and into the gauge, thought that if the rim of the gauge were made very acute, having a sharp knife edge and equal angles both inside and outside the gauge, any rain which might strike upon the outer angle on one side of the gauge might be thrown into the gauge. Rain striking upon the inner and opposite side of the gauge would be thrown out, and so an equilibrium rim would be constructed, as the gain on one side would be balanced by the loss on the other side.

With this view, the author had an 8-inch gauge made and tested alongside of an 8-inch Glaisher gauge. The sloping lip of the Glaisher gauge had an angle of 45° from the perpendicular, and the rim of the equilibrium gauge was ·8 in. deep, ·18 in. in thickness, sloping off on both sides at an angle of 3° from the perpendicular. Both gauges were fixed at Croydon, 4 feet above the ground, and 259 feet above the Ordnance datum. These gauges had been working side by side for 551 days, from January 5, 1878, to July 5, 1879, during which period rain or snow has fallen upon 306 occasions. Upon 43 occasions it was found that the rain collected in the Glaisher gauge exceeded, by a small amount, the rain in the equilibrium rim-gauge, and on two occasions the quantity in the new gauge exceeded that in the Glaisher gauge. Upon 261 occasions the rain in both gauges was absolutely equal. On all occasions, it should be observed, the rain from both gauges was invariably measured in the same graduated measuring glass. On the 45 occasions when the Glaisher gauge collected most rain, the wind without exception was high. On the two occasions when the equilibrium rim-gauge collected more rain than the Glaisher gauge, it was probably due to dew, the equilibrium gauge presenting a larger surface for condensation than the other gauge. As the Glaisher gauge was not calculated to contain snow, all falls of snow are recorded in the equilibrium rim-gauge, which is constructed to hold about one foot in depth of snow.

The total quantity of rain collected in the Glaisher gauge during the period of observation, plus the snow as caught in the equilibrium rim-gauge, was 46·68 in., and the quantity collected in the equilibrium rim-gauge was 46·45 in., showing a difference of but half per cent. In all probability, however, the small excess measured by the Glaisher gauge would tend to compensate for the losses by evaporation in periods of small rainfall and at other times, and therefore, as a measuring gauge, the Glaisher pattern of gauge, when tested by a gauge of the description mentioned, gives results in practice which may be taken as correct.

Summary of Results.

Date	Total number of days' experiments	Number of days when rain fell	Amount of rain collected by Glaisher Gauge	Amount of rain collected by Equilibrium Rim-Gauge	Times when Glaisher Gauge in excess of Equilibrium Rim-Gauge.	Times when Equilibrium Rim-Gauge in excess of Glaisher Gauge
1878			Inches	Inches		
January . . .	31	17	1·145	1·115	6	—
February . . .	28	15	1·440	1·430	2	—
March . . .	31	10	1·300	1·295	1	—
April . .	30	17	3·940	3·940	0	—
May . . .	31	22	3·480	3·460	4	—
June . . .	30	13	3·205	3·190	1	—
July . . .	31	11	·595	·600	0	1
August . . .	31	20	5·725	5·690	7	1
September . .	30	11	1·015	1·010	1	—
October . . .	31	18	2·140	2·135	1	—
November . .	30	22	3·775	3·735	8	—
December . .	31	20	1·460	1·455	1	—
1879						
January . . .	31	13	2·610	2·610	0	—
February . . .	28	22	3·380	3·360	4	—
March . . .	31	13	·540	·540	0	—
April . . .	30	19	2·535	2·515	4	—
May . . .	31	18	3·600	3·595	1	—
June . . .	30	20	3·690	3·680	2	—
July . . .	5	5	1·105	1·095	2	—
Totals . .	551	306	46·680	46·450	45	2

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10. *An Anemometer for Measuring the speed of Smoke or Corrosive Vapour.* *By* Alfred E. Fletcher, *F.C.S.*

In the year 1869 I had the honour of reading a paper descriptive of an anemometer I had contrived for measuring the speed of currents of air, which, being highly heated or containing corrosive gases, forbad the use of the instruments hitherto in common use. These all have moving parts, wheels, pivots, &c., which would be destroyed or rendered useless by great heat or acid vapours.

My anemometer consists of a bent tube and a straight one, which, together, are thrust into the current whose velocity is to be measured, the outer ends of the tubes being connected by means of flexible tubing with a delicate manometer for determining the difference there may be between the pressures exerted in the two tubes.

The manometer I prefer, and which I have for many years constantly used, is a simple U tube partly filled with ether. One of the flexible tubes being connected with each limb of the U tube, the position assumed by the ether is an indication of the difference of the pressures exerted on it. If the pressures are equal, the surfaces of the ether in the two tubes remain level one with the other. To measure the deviations from this normal position, finely-divided scales provided with a vernier are employed. In the hands of some who use the instrument, so fine a measurement is found to require too delicate handling, and too close an observation. To obviate this, or to assist the observer, I have introduced in the

present instrument magnifying glasses in front of the columns of ether, carrying a line to guide the eye while the vernier scales and the horizontal lines which are to be adjusted to the ether surfaces are drawn on glass, so as to admit of light shining through. This arrangement affords, therefore, a means of magnifying optically the small motions of the ether, instead of doing the same by mechanical means, as has been attempted by some.

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11. *On an improved Rain Gauge.* *By* N. LOWENTHAL LONSDALE.

This gauge records the *exact* quantity of rain and *snow* on paper as well as on a tell-tale dial. The funnel is suspended on an enclosure with a sloping roof and two air pipes, within which enclosure, in winter, a small flame is kept burning to melt the snow in the funnel. From the funnel the water runs into an intermediate receiver, which can be closed by a valve. When open, the water runs on into a larger receiver, where a float with a tube in the centre rises and falls. This tube is closed at the top, and embraces a long open tube fixed in the centre of the large receiver, the two together thus forming an intermittent siphon, the diameters of the inner and outer tubes of which must be, at least, as 2 to 3. To the top of the float is fixed a rod with a pencil, for marking a sheet as usual. The rod also moves an index which marks whole inches, and another for fractions.

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12. *On a Galvanometer for demonstrating the Internal Current transmitted through the Liquid within a Voltaic Cell.* *By* CONRAD W. COOKE, *C.E., M.S., T.E.*[1]

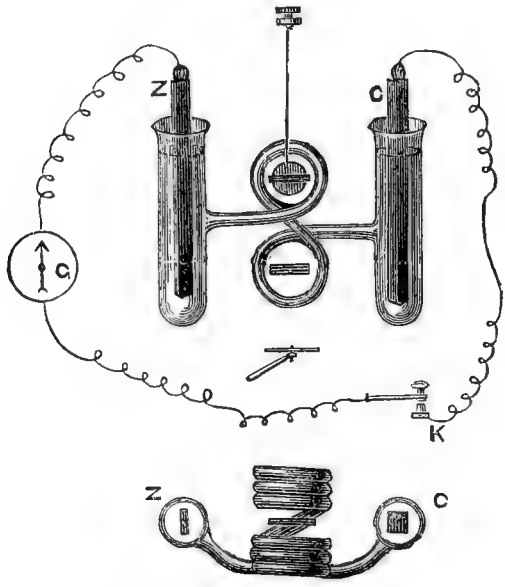
It is of course well known that when the external circuit of a voltaic cell is closed a current of electricity is transmitted through that circuit, and at the same time a current of equal strength is transmitted through the liquid within the cell from one plate to the other. The former of these is detected by its electro-magnetic and electro-chemical effects, producing deflections in galvanometers and electroscopes and sounds in telephonic instruments, and is utilised in all the applications of voltaic electricity.

As far as the author has been able to find out, there has not hitherto been any satisfactory means in the hands of the demonstrator of physics by which the existence of the internal current within a single cell can be made apparent. Faraday, in the course of his early researches, made the following experiment: he suspended a magnetic needle by a silk thread, and lowered it into the liquid between the plates of one cell of a voltaic battery, so that its length should lie in a plane perpendicular to those of the plates; and he observed that when the needle was just below the surface of the liquid it was deflected the moment that the external current was closed. On lowering it still deeper (the current being maintained complete) its deflection gradually diminished as the depth of immersion was increased, until it reached a position about half the depth of the liquid, when it returned to zero; and after passing this depth it was again deflected, but this time in the opposite direction, its amount of deflection in either case increasing as its distance from the neutral or central point was increased. The cause of this phenomenon is obvious from the following considerations:—If a wire conveying an electric current be held *above* and parallel to a magnetic needle, the latter, obeying Ampere's law, will be deflected with an angular displacement dependent upon the strength of the current and its distance from the needle; and if the same wire be held *below* the needle, the latter will be similarly deflected, but in the opposite direction. Now the flow of electricity through the liquid in a voltaic cell may (for the purpose of this explanation) be looked upon as made up of an infinite number of currents transmitted in a horizontal direction from one plate to the other; and when a magnetic needle is immersed just below the surface of the

[1] This Paper was printed *in extenso* in *Engineering*, August 29, 1879.

liquid, a series of currents are flowing in one direction below it, and a corresponding deflection takes place; when, however, it is lowered deeper into the solution a certain number of currents are flowing below it tending to deflect it in one direction, and a certain number are flowing above it tending to deflect it in the opposite direction, and its permanent deflection is due to the electro-magnetic effect of the difference between the two. When these become equal, as they are when the needle is at the middle of its depth, their effects on the needle are balanced and neutralised, and no deflection takes place; and when that point is passed the currents above the needle are in excess of those below it, and a corresponding deflection in an opposite direction is given to the needle.

Professor Hughes, by placing in the circuit of a battery an apparatus, such as a clock-microphone, or a key, by which an intermittent or undulatory character



may be given to its current, and holding one side of a rectangular coil of wire in circuit with a Bell telephone over one of the cells of his three-cell battery, a secondary intermittent or undulatory current was induced in the coil by that portion of the primary circuit transmitted through the cell, and a corresponding ticking was heard in the telephone.

In both these experiments, however, the effects observed must be attributed rather to the external current of the other cells than to the internal current of the cell under examination; and the author is unaware that any successful attempt has hitherto been made to construct an instrument which shall utilise *the whole* of the internal current of a single voltaic cell for the production of electro-magnetic effects. While engaged in some experiments a few years ago it occurred to the author that if a voltaic cell were divided into two portions, having the zinc element in one portion, and the positive element in the other, and the solution contained in the one portion were connected to that in the other by a tube filled with the same liquid, the tube being coiled round a magnetic needle, a deflection of the latter, due to the current within the cell being forced by the convolutions of the tube to circulate around the needle, would be produced when the two elements were connected together. An apparatus (which was before the section) was then constructed. This instrument consists of two glass test tubes united together by a small tube about two feet long, and convoluted into two circular coils after the manner of a Thomson's Reflecting Galvanometer. Within the coils is suspended an astatic system of magnetic needles, of which the upper carries a light mirror by which its deflections

may be made apparent by the movement of a spot of light on a screen. It may therefore in this respect be looked upon as a Thomson's Reflecting Galvanometer, coiled with liquid instead of with metallic wires. The elements are placed one in each of the little cells, and may be connected by a key; or, by placing a reflecting galvanometer in the external circuit, both currents may be simultaneously indicated on the screen, and their interdependence or identity be demonstrated.

The author is indebted to Mr. Gimingham, whose name is now inseparably connected with the splendid researches of Mr. Crookes, for being able to produce the instrument on the table, in which the tubes and coils are of glass, all in one piece, and is a very beautiful specimen of accurate glass blowing. Below the base of the instrument is a fine slightly magnetised sewing needle, which can be rotated on a vertical axis through a small angle by means of a little lever, and by which the instrument may be adjusted to zero.

TUESDAY, AUGUST 26, 1879.

The following Reports and Papers were read:—

1. *Report of the Committee on Astronomical Clocks.*
See Reports, p. 131.

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2. *Report of the Committee on Rock-conductivities.*
See Reports, p. 58.

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3. *Report of the Committee on Instruments for detecting Fire-damp in Mines.*—See Reports, p. 131.

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4. *Suite des Recherches sur la Photographie Solaire.*
Par Dr. J. JANSSEN, *de l'Institut de France.*

La nouvelle méthode est fondée sur trois conditions—

1. L'achromatisme chimique de l'objectif, qui est fondé sur le maximum d'action dans le spectre photographique.

2. L'extension de la grandeur des images qui ont été portées successivement à 20, 30, 50 centimètres de diamétre.

3. Le temps de pose, qui a été réduit jusqu'à $\frac{1}{3000}$ et quelquefois $\frac{1}{5000}$ de seconde.

Résultats.—Ces photographies ont montré que les formes admises pour les granulations n'étaient pas exactes.

Les formes sont celles de nos nuages atmosphériques, sauf qu'au lieu de vapeur d'eau ce sont des poussières métalliques solides ou liquides qui forment les nuages solaires.

Les photographies ont montré à la surface du soleil l'existence du *réseau photographique*—c'est-à-dire, que la surface solaire est divisée en régions de calme et d'activité relatives.

Les dernières études ont montré que les formes et la grandeur des polygones du réseau photographique sont variables, ce qui montre que les émissions gazeuses du soleil sont soumises à des périodes, qui sont sans doute en rapport avec les périodes des taches.

Le Dr. Janssen étudie en ce moment les mouvements dont la surface solaire est le siége.

Pour cette étude il a institué des expériences par lesquelles une même portion de la surface solaire est photographiée à courts intervalles (2 secondes, 1 seconde, ½ seconde, etc.) sur la même plaque. Il opère aussi avec deux lunettes photographiques, qui donnent, soit au même instant soit à des intervalles déterminés, deux images d'une même portion de la surface solaire.

Ces études, qui sont en cours, montrent déjà que la surface solaire est le siége de mouvements d'une violence dont nos phénomènes terrestres ne peuvent donner aucune idée. L'étude de ces mouvements dans ses rapports avec ceux des protubérances révélées par le spectroscope conduira sans doute aux plus importans résultats sur la physique solaire.

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5. *Sur l'Application du Révolver Photographique à l'Etude des Eclipses Partielles et à celle des Mouvements des Animaux.* *Par* Dr. J. Janssen, *de l'Institut.*

Le Dr. J. Janssen explique qu'à l'aide du *révolver photographique*, qui a été imaginé à l'occasion du passage de Vénus, on pourra obtenir des photographies successives des éclipses partielles, et que l'inspection ou la mesure de images conduira à la connaissance du temps des contacts et à celle de la position relative des astres.

En modifiant les dispositions du *révolver* M. Janssen montre qu'on pourra aussi l'appliquer à l'étude des mouvements des animaux, soit pendant la marche soit pendant le vol. M. Janssen s'occupe de ce sujet.

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6. *Further Results of Experiments on Friction at High Velocities.* *By* Captain Galton.—See Section G., p. 508.

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7. *On the Bursting of Firearms when the Muzzle is closed with Snow, Earth, &c.*[1]—*By* Professor George Forbes, *F.R.S.E.*

This well-known fact is explained in a simple manner. If the charge moved slowly of course a very small pressure of air would drive out the obstacle, which offers a very small resistance. But in practice a charge travels with a speed of more than 1,000 feet a second, the velocity of sound, and greater than the velocity with which the pressure of air in front of the charge can be transmitted along the bore. Consequently we have a layer of air in intense pressure in front of the charge, and the obstruction cannot be forced out until this layer reaches it, so as to give it the velocity of the charge in the time taken for it to leave the muzzle. The mathematical investigation shows that the pressure generated with a plug of the density of air is 7½ tons. This pressure is independent of the size of bore of the gun and of the length of the plug.

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8. *Note on the Constancy of Capacity of Certain Accumulators.* *By* Dr. Alexander Muirhead, *F.C.S.*

The object I have in view in making this communication is to draw the attention of Section A of the British Association to the desirability of issuing a temporary standard of electrical capacity, the want of which has considerably increased

[1] This investigation is given with the numerical calculation in the 'Proceedings of the R. S. E.' 1878–9.

since the last Report of the Committee on Electrical Standards, September 4, 1867.

At that time it was thought worth while to issue a provisional unit of capacity to meet the requirements of the electric telegraph service, in the shape of a mica-paraffin condenser of capacity to be determined by the ballistic method; but according to the Report no decision had then been arrived at whether the new unit should be issued by the Committee or on Professor Jenkin's own responsibility. In an appendix to that Report, Professor Jenkin has published the results of several determinations of the capacity of a certain condenser of Mr. Latimer Clark's construction, adjusted to equal 10^{-14} electro-magnetic absolute units; in the values he obtained there was an approximation of only ·42 per cent. between the mean and any single result, so that copies of such a preliminary standard would probably not have been correct within much less than 1 per cent.

This apparent variation of capacity was due chiefly to the absorption of charge by the dielectric used to separate the conducting plates; and, I believe, this condenser, and others made like it at the time, have failed altogether in insulation since.

In 1869 I carried out a series of experiments for Messrs. Clark & Muirhead, to determine the best and most durable dielectric to use in the construction of condensers for the electrical testing and working of submarine telegraph cables, and I soon found that a given dielectric absorbed less, the freer it was from foreign matter. The materials that seemed best suited for the purpose were paper, mica, paraffin, and shellac. Several condensers were made in the manner described by Professor Jenkin in Appendix IV. to the above-mentioned Report, in which these materials were used, purified in different ways, great care being taken in every case to prevent the deposition of moisture on the plates during the construction of the condensers. The plates that showed the least amount of absorption, with ordidinary differences of potential, were those made of mica coated with shellac, that had been purified with absolute alcohol. The condenser which I now exhibit was constructed of such plates, and its capacity adjusted to equal one-third of a microfarad on comparison with four condensers lent to me by Mr. Latimer Clark and Mr. Forde, one of which was the condenser referred to above in Professor Jenkin's report, and the other three were made from it by Messrs. Laws and Lambert, assistants to Mr. Latimer Clark. According to my own determinations at the time, by the ballistic method, using a needle whose period of vibration was 8 seconds, its value was ·331 microfarad, and I decided to take as correct the mean ·332 of this, and the value ·333 got by comparison with the four condensers referable to Professor Jenkin's determinations. Ever since then, copies have been made of this condenser and supplied by Elliott Bros., the late firm Warden & Co., and Clark, Muirhead & Co. to manufacturers of scientific apparatus and others as standards; the number so issued is over 600. From the close agreement of the determinations just made by Mr. Hockin (a member of the late Committee on Electrical Standards), of the capacity of this condenser with mine made nine years ago (*vide* his note appended to this), it will be seen that probably no change greater than one-third per cent. has taken place in it, and, therefore, one might confidently recommend the British Association either to adopt this form of condenser as their temporary standard, or to appoint another committee to re-investigate the subject. I might add that I found very little absorption in condensers of brass plates embedded in paraffin wax allowed to solidify under pressure, and also in some made with silvered glass plates embedded in the same manner. In the absolute determination of the capacity of these condensers by discharge through a galvanometer, no greater differences than one-third per cent. need be made in the results, even with needles varying in period of vibration by as much as from $2\frac{1}{2}$ seconds to 25 seconds. This is the result of experience; and in defining the capacity it will be sufficient for all practical purposes to specify complete saturation of the condenser and the method of measurement adopted.

I have asked Professor Ayrton to draw the attention of the Section to the fact that there is no one authorised to certify to the correctness of copies of the various electrical standards originated by the British Association. I would suggest that some public body, such as the Kew Observatory, be asked to undertake

the labour of comparing resistance coils, condensers, absolute electrometers, &c., against the standards to be lodged by the British Association for the purpose.

Value of the condenser from comparison with four condensers lent by Messrs. Clark and Forde 1869 . . . } ·333 mf.
Value of condenser determined by Dr. Muirhead, January 1870, from throw of galvanometer needle . . . . } .331 mf.
Values obtained by fall of potential through small resistances—10,000—vary according to time; for short time, ·001 sec., the condenser comes out ·3305; for much longer time, ·1 sec., its capacity comes out ·335.

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9. *Note on the Capacity of a certain Condenser, and on the value of V.* *By* C. Hockin, *M.A.*

The observations given in this paper were first begun with the object of re-determining the value of the capacity of certain condensers employed in the practical testing of cables, and in terms of which the capacity of many cables now submerged have been recorded and published.

Dr. Muirhead and Professor Ayrton stated to me that they proposed to draw the attention of the British Association to the desirability of recognising some one condenser or condensers as a provisional standard.

Fully concurring in their views on this point, I have determined in various ways the capacity of a condenser made by Dr. Muirhead several years ago, and the particulars of which he has given in his paper.

The agreement of the value of the condenser now with the value it had when first made is satisfactory, as showing the permanence of a well made condenser.

The order of the experiments made was as follows:—

1. A condenser was built up of silvered glass plates insulated from each other by three small fragments of shellac.

2. The capacity of the glass condenser was determined by the 'ballistic' method, the deflection of a Thompson's galvanometer needle being observed.

3. The glass or air condenser was compared with three other condensers by the null method, that is to say, the glass condenser was charged to a definite positive, say, potential, and one of the other condensers to some lower negative potential such that when the two condensers were connected the potential of each fell to zero immediately after the connection.

4. The capacities of the three condensers last mentioned were determined by the throw of the needle of a Thompson's galvanometer moving freely, and having a period of oscillation which was varied from 2·9 seconds to 25 seconds.

5. The rate at which the condensers lost their charge when the opposite plates were connected by a known large resistance was determined.

6. A correction in one case has been applied for absorption determined by observing the rate at which the potential of the condenser varied when after discharging through a known resistance for given times, the circuit of the high resistance was suddenly broken.

The glass condenser was thus made.

A hundred circles of the best flat plate glass were obtained and silvered on both sides by the chemical process. They were supplied by Messrs. Farmiloe & Sons.

These were carefully examined, and any spots observed not covered by the silver were covered with gold leaf secured by a little very weak gum or by a trace of lard.

Connection was made with the surfaces of the glass plates by soldering a thin copper wire to them with an alloy of cadmium and bismuth melting at a very low temperature.

Fifty plates had a diameter of 127 mm. and 50 were of considerably greater diameter.

The plates were built up thus.

A plate of shellac was made with flat sides by pouring melted shellac on a

stout plate of glass about 12 mm. thick, and pressing the melted lac into a disc by another similar plate of glass, the two plates being separated by slips of thin glass.

The plate so pressed was cut into small pieces, and the thickness of each piece measured, the fragments having the same thickness (within $\frac{1}{1000}$ of an inch) being placed together.

A stout piece of good plate glass was covered with tin-foil, and on this in proper position three little pieces of lac were laid to support the first small circle of glass; on this three other pieces were placed over the first three pieces to support the first large circle, and so on to the end. Care was taken to select the three pieces supporting each plate of the same thickness.

The mean distance between the plates was determined by measuring the height of the pile when completed, and the height after removing the shellac separating the plates.

The mean area of the shellac by weighing the fragments used and comparing their weight with that of a piece of the plate from which they were cut of such size that its dimensions could be measured with some accuracy.

The three other condensers used (called A, B, C) were—

A. The condenser referred to in Dr. Muirhead's paper.

B. A condenser made by Messrs. Warden & Clark at some time not known by me and used for comparison.

C. A small mica condenser, capacity about 0·1 mfd. made in 1867, and copied from the condenser described by Professor Jenkin in his paper, 'British Association Reports,' 1867.

The method of observation was as follows:—

a. The time of oscillation of a galvanometer needle was observed.

b. The deflection of the galvanometer needle produced by a steady current was noted, the current being either that produced by the battery employed to charge the condenser flowing through a resistance of from 500,000 to 1,000,000 ohms, or else a current produced by any other battery, the electromotive force between two points in the circuit separated by a known resistance being determined in terms of the electromotive force employed to charge the condenser.

c. The condenser was charged and discharged several times. As it was found impracticable to maintain the galvanometer needle at rest absolutely when the time of oscillation was great, the method employed was to reduce the oscillations to a small amount, 2, 3, or 4 divisions, read three successive oscillations and discharge the condenser at the moment that the needle was at rest, and on the point of changing its direction of motion. The mean of the second deflection and the half sum of the first and third deflections is taken as the zero, and the total excursion of the needle in the case in question is not altered by the fact that the needle started from a position of rest but not of equilibrium.

In fact, let Θ be the angle defining the extreme excursion of the needle due a given impulse applied to it when it was at rest in a position of equilibrium.

θ the extreme excursion when the impulse is applied, when the position of the needle is defined by the angle θ, and is oscillating through an angle θ_2 on either side of its zero point. Then (neglecting the effect of air resistance)

$$\Theta = \sqrt{\theta^2 - \theta_1^2} \pm \sqrt{\theta_2^2 - \theta_1^2}$$

and, therefore, if $\theta_1 = \theta_2$, or the impulse is applied at the moment the needle is at the extremity of an excursion,

$$\Theta = \sqrt{\theta^2 - \theta_1^2}$$

$$= \theta\left(1 - \tfrac{1}{2}\frac{\theta_1}{\theta}\Big|^2 + \text{\&c.}\right)$$

$$= \theta \text{ if } \frac{\theta_1}{\theta}\Big|^2$$

may be neglected, as it may in all the cases occurring in these experiments.

d. Experiment *b* repeated.

e. Experiment *a* repeated.

f. The coefficient due to damping was determined. An oscillation being set up, a number of swings of the needle were observed, and the log. decrement of the deflections calculated.

Let θ_1 and $\theta n+1$ be two excursions of the needle measured on the same side of the zero and separated by n complete oscillations.

$$\text{Let } \frac{1}{n} \log \frac{\theta_1}{\theta n+1} = \log a.$$

Then if θ is the observed excursion of the needle due to an instantaneous impulse applied when the needle was at rest near the zero point, and $\beta.\theta$ the excursion that would have occurred had there been no resistance to the motion of the needle,

$$\beta = a^{\frac{1}{2\pi} \tan^{-1} \frac{2\pi}{\log a}}$$

If we write $a = 1+z$ where z is small,

$$\beta = 1 + \frac{z}{4} - z^2\left(\frac{3}{32} + \frac{1}{4\pi}\right) + z^3\left(\frac{7}{128} + \frac{3}{16}\cdot\frac{1}{\pi^4}\right) - z^4\left(\frac{77}{2408} + \frac{55}{384}\frac{1}{\pi^2} - \frac{5}{96}\frac{1}{\pi^4}\right) + \text{\&c.,}$$

or

$$\beta = 1 + 0{\cdot}25000z - 0{\cdot}11908z^2 + 0{\cdot}07369z^3 - 0{\cdot}05158z^4$$

—a convenient expression sufficiently accurate for most practical cases.

The time of oscillation was determined as follows:—The needle was brought to rest, started by discharging a condenser through the galvanometer exactly at the beat of a chronometer; by listening to the beats the periods of the first five swings of the needle were observed and registered, a certain number (usually ten) of oscillations were then counted, and the periods of five successive swings again measured, and so on.

The mean of the first five observations, the second five, and so on were treated as the time of the 2nd, 16th, 30th, &c., oscillation. No sensible change in period due to extent of oscillation was observed.

In this manner results agreeing within 0·1 per cent. were readily obtained.

The galvanometer was inclosed in an iron chest of $\frac{3}{4}$ in. wrought iron with a small opening to admit the light to the needle. The zero of the instrument remained very constant even when the period of oscillation was large—25 seconds for example.

The needles were made of little pieces of watch spring hardened and well magnetised; the lower series being attached to a brass disc fixed to an aluminium wire perpendicular to the plane of the disc, and vertically over its centre.

The results obtained are now given:—

Glass condenser as first set up.

1st series of experiments			Cap. = 0·00697	mfds.
2nd	,,	,,	,, = 0·00694	,,
3rd	,,	,,	,, = 0·00696	,,
	Mean		0·00696	,,

Condenser A = 0·3324 mfds. } By comparison with glass condenser—
„ B = 0·3261 „ Thompson's method.
„ C = 0·0995 „ }

Condenser A = 0·3312 } By direct measurement, the time of oscillation
„ B = 0·3255 } of the needle being 16·8 sec. approximately.
„ C = 0·1026 }

The discrepancy in the two values of C is due to the great absorption noticed in this condenser.

The value of B is also rather too large from the same cause.

The surfaces of forty-nine plates of diameter 0·127 mm., and separated by an average distance of 1·623 mm. from the larger plates, were discharged in this case, giving for v, without corrections, the value 296×10^6 – m. per second. The correction for the greater induction through the pieces of shellac is $+3 \times 10^6$, and for the edges of the plate -1×10^6, giving for v the value 298×10^6.

The condenser was then taken to pieces and set up again. In the second case the larger plates were separated by pieces cut from a plate of flat plate glass, and the smaller plates resting on them were insulated by three very small fragments of shellac.

The distance of the surfaces was determined in this case differently. Fifty small plates were used. The 150 slips of glass separating the larger plates were cleaned with nitric acid, brushed with a camel's hair pencil, and piled on each other on an inclined metre scale, and the total height measured several times.

The small plates were brushed in like manner, placed on each other, resting on a plate of flat glass, and another large stout plate placed on them, with a weight of about 3 kilos. The distance between the glass plates was measured with a pair of inside calipers at four points on a circle, concentric with the pile of small plates. From the data thus obtained the average distance apart of the inducing surfaces was estimated. The result was as follows:—Fifty plates, diameter 127 mm., distant 2·362 mm. from larger plates. Capacity, 0·005007 mfds.,

Whence	$v = 299{\cdot}5 \times 10^6$
Correction for edges . .	$-1{\cdot}0 \times 10^6$
„ shellac . .	$+0{\cdot}3 \times 10^6$
Final result . .	$298{\cdot}8 \times 10^6$—say 299.

A further slight correction should have been made for the connecting wires and for the small quantity of solder on each plate, but the corrections will not be sensible within the degree of accuracy obtained by the measurements.

The final result, 298,000,000 metres per second, agrees closely with that obtained by Professor Ayrton, whose method (nearly) is adopted, and with the best value of the velocity of light determined by direct experiment.

A great many measurements of condensers A and B were next made by the ballistic method. I give only the result of each set of experiments here, leaving the figures for a supplement, to show the sort of accuracy obtained in observation.

	Time Oscillation. Seconds.	Capacity of A in mfds.	Capacity of B in mfds.	
1	7·79	—	0·3276	
2	16·80	—	0·3214	
3	7·784	—	0·3218	
4	16·76	0·3312	0·3255	Mean of three sets.
5	25·12	0·3272	—	
6	× 25·00	0·3241	0·3167	
7	× 12·88	0·3248	0·3176	
8	12·32	0·3314	0·3247	
9	12·30	0·3305	0·3234	
10	2·923	0·3310	0·3219	

Sets 6 and 7 I have put down, but they may fairly be neglected, I think,

because the batteries were found next day not to be in good order. In taking the mean I reject them, and find

$$\left.\begin{array}{l}\text{Cap. A} = 0{\cdot}3306 \\ \text{,, B} = 0{\cdot}323\end{array}\right\} \text{mfds.}$$

To determine the capacity by loss of charge the connections were arranged as below.

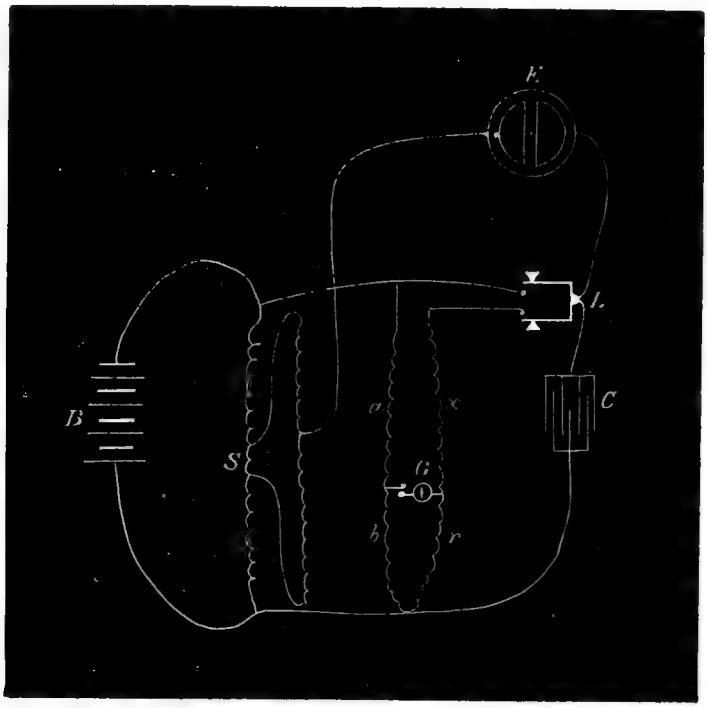

FIG. 1.

B is the battery, *s* a Varley's 'slide resistance,' dividing the potential into 10,000 parts.

a, a resistance in pt. a g wire = 200,000 ohms.

b, a variable resistance.

x, a selenium resistance from 200 megs. to 270 megs.

r, a pt. a g wire resistance = 1,000,000 ohms.

The resistances *a* and *r* were lent me by Mr. H. A. Taylor, who had made them with great accuracy, and in conjunction with whom a few of the observations now given were made.

The selenium resistances were made by Mr. Bassett; the selenium bars were sealed in glass tubes with platinum terminals. The tubes inserted in holes bored in a plate of ebonite and filled in with paraffine wax, ensuring a very high degree of insulation.

C is the condenser, K a Lambert's discharging key, E a Thomson's quadrant electrometer, and G a sensitive galvanometer.

The method of observation was as follows:—

α. *f* and *g* were pressed down and *b* adjusted, so that $x:r = a:b$.

β. At a given instant *g* is raised and the slides gradually moved to the expected position of the spot after the condenser had discharged itself for the proper time.

γ. At a given instant *f* is raised, the slide reading, and position of the spot noted as soon as possible, and also after given intervals.

δ. Observation *α* repeated.

In this way the following results were obtained for condenser B (corrected for absorption):—

Time of Insulating Condenser. Seconds.	Capacity of B.
5	0·3095
10	0·3160
15	0·3175
20	0·3232
25	3207
30	3224
35	3244
40	3203
45	—
50	3224
60	3216 3224

Omitting the first value, as 5 seconds is too small a period to be measured accurately by ear, the mean capacity of condenser B becomes 0·3211.

Without assistance I was unable to repeat with the same accuracy the experiments with condenser A. There was much less absorption with this condenser, but greater leakage, owing, I believe, to the surface of the ebonite a good deal. The mean of all values gave for A the capacity 0·332 mfds.

If, therefore, the capacity of A is defined as the apparent capacity, determined by the throw of a galvanometer with a period of between 3 and, say, 15 seconds, I think the value 0·331 mfds. will be correct to the last figure.

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10. *On an Electrical Gyrostat.* *By* Professor G. Forbes, *F.R.S.E.*

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11. *On the Condition which must be fulfilled by any number of Forces directed towards Fixed, or Movable, Centres, in order that any given curve should be described freely by a particle acted on by these Forces simultaneously; and an analogous Problem.* *By* Arthur Hill Curtis, *LL.D.*

I. When a particle describes a curve freely under the action of any number of forces the equations of motion can be reduced to the two foollowing:—

$$v^2 = F_1 \frac{c_1}{2} + F_2 \frac{c_2}{2} + \&c. \quad . \quad . \quad . \quad . \quad (1)$$

$$v dv = -(F_1 dr_1 + F_2 dr_2 + \&c.) \quad . \quad . \quad . \quad (2)$$

$$\text{or } v^2 = \Sigma F \frac{c}{2}, \; v dv = -\Sigma F dr,$$

F_1, F_2, &c., being forces acting along r_1, r_2, &c., and tending to diminish them, while c_1, c_2, &c., are the chords of curvature coinciding in direction with these lines respectively, and dr_1, dr_2, &c., are the projections on them of the element of the curvilinear path of the particle.

From the above equations the following equation results:—

$$\Sigma \left\{ F (dc + 4 dr) + c d F \right\} = o, \quad . \quad . \quad . \quad (3)$$

but, if ϕ_1, ϕ_2, &c., denote the forces respectively codirectional with F_1, F_2, under which *singly* the given curve would be described, we must have, as particular cases of (3), $\phi_1 (dc_1 + 4 dr_1) + c \, d\phi_1 = o$, $\phi_2 (dc_2 + 4 dr_2) + c_2 \, d\phi_2 = o$, &c., &c.

$\therefore dc_1 + 4\ dr_1 = -\frac{c_1\, d\phi_1}{\phi_1}$, and $\therefore$ from (3) $\Sigma\, c \left(d\mathrm{F} - \frac{\mathrm{F}d\phi}{\phi}\right) = o$, or

$$\Sigma\, c\phi\, d\left(\frac{\mathrm{F}}{\phi}\right) = o \quad . \quad . \quad . \quad . \quad . \quad (4)$$

which is the condition sought, and must be *identically* true for every point on the curve, the initial velocity being given by the equation $v_o^2 = \left(\Sigma\ \mathrm{F}\,\frac{c}{2}\right)_o$.

One consequence of the condition (4) is that if an orbit be describable by a particle under the action of *each* of a number of forces, acting towards fixed, or movable, centres, including the case where some of the centres may be at an infinite distance, this orbit can also be described by a particle acted on by these forces *simultaneously*, each being multiplied by an arbitrary constant, while the square of the initial velocity is the sum of the squares of the initial velocities corresponding to the forces separately, these squares being multiplied by the same constants respectively. Any laws being assumed for all the forces, F_1, F_2, &c., *except one*, the equation (4) determines the remaining force. Special applications to an ellipse, the forces being directed towards the centre and foci, are made in the paper.

II. A condition identical with (4) exists in the case of a string acted on by a number of forces and in equilibrium in any given form.

Special applications to the case of an ellipse, the forces being directed towards the centre and foci, are made in the paper.

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12. *On a Theorem relating to the Transformation of Series.* *By the* Rev. S. Earnshaw, *M.A.*

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13. *Improved Photographic Screens.* *By* J. H. Starling, *F.C.S., A.I.C.*

There have been many attempts from time to time to devise a particular form of lens-covering or cap for photographic cameras which would permit the operator to expose or cover the lens as quickly as possible, and with the least possible disturbance of the apparatus.

The old and usual form of cap cannot be said to fulfil these requirements, since the rapidity of manipulation depends entirely upon the operator. Moreover, however skilfully this is used, it is almost impossible to avoid disturbing the apparatus more or less.

The spring sliding shutter, which is by no means a new invention, although an improvement as regards mere mechanism in the above, can only be used for rapid working. A third form of lens-covering has been devised by a Mr. Cadet, which consists simply of a circular disc, which can be made to open or shut externally or internally on an ordinary hinge by means of suitable mechanism.

It occurred to the inventors that the kind of covering which would meet the practical requirements necessary for the perfect working of a camera must be one which should open if possible from the centre, and be so under the control of the operator as to be opened or shut either rapidly or slowly, and at the same time noiselessly, so that it might be used either for landscape, photography, or portraiture.

The present invention, which I have the honour of bringing before your notice, may without doubt be said to fulfil these somewhat difficult conditions.

By means of a suitable transmitting power, which may be used at any required distance from the camera, the covering, which you will perceive consists of two peculiarly curved halves, is caused to be opened or shut much in the same manner as a pair of shears, thus exposing the lens from the first at the centre, and gradually increasing the opening towards the circumference. This may be done rapidly or

slowly, as you perceive the cover is placed inside the camera, and when in perfect order may be worked noiselessly.

NOTE.—*Can be kept open any length of time without exertion. Can be closed instantaneously. No vibration.*

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14. *On a Binocular Spectroscope.* *By* G. JOHNSTONE STONEY, *M.A., F.R.S.*

In this instrument, which is not yet finished, there will be two collimators placed parallel to one another, provided with horizontal slits which lie in the same right line. The telescopes will also be parallel, and will be in a convenient inclined position. Between them lie the prisms, which are a semiprism, a complete prism, and another semiprism of bisulphide of carbon, plunged in a tank of water, and connected by Mr. Grubb's simple automatic motion, which consists of a link and two cogged wheels. The angles of the prisms will be large, their faces disks of optical glass five inches square, and the collimators and telescopes are of two-inch aperture. With this instrument the spectrum will be spread out vertically, and the lines in it will be horizontal.

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15. *On a Simple two-prism Automatic Motion.*
By G. JOHNSTONE STONEY, *M.A., F.R.S.*

In this arrangement, which is easily constructed by an amateur, and which has worked for a long time satisfactorily, the collimator and telescope are fixed on two boards, A and B, jointed together by a hinge, the prisms stand on little wooden tables, *a* and *b*, which turn on pivots fixed in the boards, A and B, under the middles of the first and last surfaces of the prisms respectively. The motion of each of these tables is trammelled by a link, connecting a projection from the front of the table with a point on the front of the board upon which it does not stand, the radius from the first end of the link to the pivot on which the little table turns being four times the radius from the other end of the link to the hinge of the boards, and these radii being parallel to one another when the instrument is set upon the middle of the spectrum. Thus the table *a* is connected by its link with the front of the board B, and the table *b* with the board A. Strips of brass are let into the wood to receive the holes in which the pivots and links work, and the links are also of brass. One of the links is arched upwards and the other downwards, sufficiently to clear each other. Pencilled lines are drawn on the little tables to mark the proper positions of the prisms, so that they can be replaced without delay after they have been removed.

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16. *On Scales of Variable Length for the eye-pieces of Spectroscopes.*
By G. JOHNSTONE STONEY, *M.A., F.R.S.*

This communication was made chiefly for the purpose of inviting the attention of instrument makers to the want of a convenient scale in the field of view of a spectroscope, the interval between the divisions of which can be varied to suit the part of the spectrum under examination. It was suggested that the property of a spiral spring, to retain the equal spacing of its spires when extended, might be made use of. A scale, of which the length can be varied, is also very much wanted for use with maps of spectra. Possibly a scale simply laid down on vulcanised india-rubber would work sufficiently well here.

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17. *On Flight and its Imitations.* *By* F. W. BREARY.

SECTION B.—CHEMICAL SCIENCE.

PRESIDENT OF THE SECTION—Professor J. DEWAR, M.A., F.R.S., L. & E.

THURSDAY, AUGUST 21, 1879.

The PRESIDENT delivered an Address.

The following Reports and Papers were read:—

1. *Report of the Committee on the Chemistry of some of the lesser known Alkaloids.*—See Reports, p. 133.

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2. *On some Relations between the Numbers expressing the Atomic Weights of the Elements.* *By* WALTER WELDON, *F.R.S.E.*

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3. *On the Synthesis of Diphenyl Propyl.* *By* M. R. D. SILVA.

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4. *Recent Researches in Explosive Agents.* *By* F. A. ABEL, *F.R.S.*

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5. *On Vapour Densities.* *By* Professor DEWAR, *F.R.S.*

FRIDAY, AUGUST 22, 1879.

The following Papers were read:—

1. *On Large Crystals of Mercury Sulphate.* *By* PHILIP BRAHAM, *F.C.S.*

The crystals exhibited had taken over two years in forming, and were due to the presence of a trace of Nitric Acid in the sulphuric in which they were formed.

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2. *On the Manufacture of Crucible Steel.* *By* HENRY S. BELL, *F.C.S., &c.*

The manufacture of crucible steel is one of the most important industries connected with the town of Sheffield, which boasts of not less than 120 firms engaged in the production of this material. Notwithstanding the enormous output of steel by the Bessemer and Siemens-Martin processes, this kind of steel is unrivalled

for the manufacture of the finer varieties of cutlery and edged tools, &c. A brief outline of the process itself is as follows:—The most of the iron employed for this purpose is imported into this country in the shape of bars from Sweden, where it has been smelted from very pure iron ores, in a blast furnace, by the aid of charcoal, and subsequently puddled to free it from impurities.

The first operation to which it is subjected, is that known as the cementation or converting process, the object of which is to combine a certain quantity of carbon with the iron; this operation is performed in a furnace of peculiar construction, where the iron and charcoal are packed together in air-tight chests or converting pots, subjected to a high temperature short of the fusing point of iron, where it remains for a matter of three weeks.

After the conversion, when the pots are cold the bars are taken out and found to be covered with blisters, hence it is termed Blister Steel. In consequence of the various theories proposed to account for this peculiar formation, the writer was induced to make a series of investigations. For this purpose he was kindly furnished by Messrs. Seebohm and Dieckstahl of the Dannemora Steel Works, with some samples of this blister steel, various portions of which he submitted to analysis, the results of which showed a marked increase of silicon where the blisters occurred, thus—

Sample 1.	Blister 2 inches in length contained	0·070	per cent. silicon.
„ 2.	Small blister contained	0·048	„
„ 3.	„ „	0·056	„
„ 1.	Unblistered portions contained	0·023	„
„ 2.	„ „ „	0·021	„
„ 3.	„ „ „	0·025	„

On inspecting one of these bars of blister steel, it is found that it has undergone both a physical and a chemical change.

The iron has now assumed a crystalline structure, and has chemically combined with a certain amount of carbon. This latter change commences on the exterior, and extends itself to the interior of the bar, if the process be continued sufficiently long, thus showing that carbonic oxide never penetrates into the centre of the bar, until the whole is converted into steel.

The writer is indebted to the kindness of the above-mentioned firm for a sample of bar iron, before and after conversion, in order to ascertain the exact chemical change that took place during the process. The following are the results obtained:—

	Before Conversion	After Conversion
Fe	99·471	98·603
C	0·352	1·250
Si	0·050	0·035
S	0·027	0·022
P	0·025	0·018
Mu	0·075	0·072
	100·000	100·000

The decrease in impurities appears greater than it really is, owing to the fact that the bar itself has increased in weight by the addition of carbon.

One remarkable fact is that, after the conversion of the iron, a quantity of the charcoal, in the converting pots, is found in a pulverised state, so as to be unfit for further use.

Some of this waste charcoal the writer has examined, and from one sample, by the aid of a magnet, he succeeded in extracting 5 to 6 per cent. of iron scale and small pieces of steel. These on being treated with dilute hydrochloric acid, evolved considerable quantities of sulphuretted hydrogen; in one case he estimated the quantity of sulphur, and found it to contain as much as 1·25 per cent. of this element. The blister steel thus produced, for the sake of convenience is divided into six different classes, viz.,

Spring heat.	Country heat.
Single shear heat.	Double shear heat.
Steel through heat.	Melting heat.

The steel is now broken up into small pieces and melted in crucibles, and cast into ingots. These are sent to the forge, where they are heated and rolled. In this part of the process the chief difficulty with which the silter has to contend is the porous or ' honey-combed ' structure of the steel.

One of the characteristic features relied on by practical men as indicating the quality of a piece of steel is the appearance of its fracture ; but this is by no means an infallible test, as the fineness or coarseness of grain can be produced by mechanical treatment or chemical means.

The characteristic property possessed by steel is its capability of being hardened and tempered. The temper of cast steel may be said to range from 0·75 to 1·50 per cent. carbon. The temper of steel is an important question in connection with the purpose for which it is required, thus a steel containing 1·50 per cent. of carbon is the class employed for razors. 1·25 per cent. is that known as ' tool temper.' Steel containing 1·00 per cent. carbon is termed ' chisel steel,' and this temper is extensively used in the arts.

The favourite marks of Swedish now employed in the manufacture of this kind of steel, are those obtained from Dannemora, the most noted of which are the 00 = Double Bullet, GL = GL, and (L) = Hoop L.

The most important of the elements which affect the quality and mechanical properties of steel are the following :

Carbon, Silicon, Sulphur, Phosphorus, and Manganese.

Carbon, by its direct combination with iron, is essentially the steel-forming element, and greatly increases the hardness and tensile strength of the metal. The maximum quantity of carbon capable of being taken up by iron is 6·5 per cent. to 7·00 per cent. This high percentage of carbon is only attained, as in the case of rich Ferromanganese, containing as much as from 85 to 86 per cent. of manganese.

Silicon.—The action of this element on steel is to produce both red and cold shortness, especially in high made steels. Under certain conditions, it is capable of imparting hardness without brittleness. The presence of this element also tends to favour a solid casting, and prevent the formation of a honey-combed structure.

Sulphur in steel, as is well known, produces ' red shortness,' and has also a tendency to prevent the chemical combination of iron with carbon, and also to displace it when in combination.

Phosphorus produces cold shortness and brittleness, but the detrimental influence of this element, when present only in small quantities, can be partially neutralised, providing the percentage of carbon is very low.

Manganese is a valuable ally of the steel melter, and serves to correct the evil effects produced by the presence of sulphur, oxygen, &c. ; and when in the state of an oxide serves to eliminate a large percentage of the silicon.

Manganese is generally introduced into the steel in the form of ' Spiegeleisen,' an alloy of iron, carbon, and manganese, generally containing about 10 per cent. of the latter element.

Other metals have been employed to replace carbon, such as tungsten, chromium, and titanium : these impart great hardness and fineness to the texture of steel.

For a considerable amount of practical information given in his paper, but necessarily omitted from this abstract, the writer is indebted to a valuable essay written some years ago on this subject by Henry Seebohm, Esq., of the firm of Messrs. Seebohm & Dieckstahl.—This paper is not intended to give any additional information to the practical steel makers of Sheffield, as to the manufacture of steel, or to offer any criticisms or advice in the matter; its object is simply to give an outline of the manufacture as it is still carried on in this town, with the hope that it may prove interesting to many of those who have come from a distance to attend the visit of the British Association, and who are unacquainted with the process which has caused Sheffield to become the great manufacturing steel centre in this country.

3. *On the Separation of Iron and Phosphorus, specially with reference to the Manufacture of Steel.* *By* THOMAS BLAIR.

The larger proportion of iron ores raised in this and most other countries contain so much phosphorus as to render them unsuitable for the manufacture of steel. Pig irons made from pure hæmatite ores, containing 0·03 to 0·06 per cent. of phosphorus, are alone suitable for this purpose. The bulk of iron made from English ores contains 0·50 to 1·50 per cent.

Steel made from phosphoretic iron is excessively brittle when cold, and is, consequently, unsuited for most purposes. In a high-class steel the phosphorus should never reach 0·10 per cent.; but in second qualities it is not unusual to find 0·20 or 0·25 per cent.

As the removal of this objectionable element is very necessary, numerous attempts have been made to eliminate it in the various stages of the manufacture of iron and steel.

M. Jacobi based a process for removing phosphorus from ores containing it as calcium-phosphate, on the fact that this salt is soluble in an aqueous solution of sulphurous acid gas; but although he effected this removal commercially, the process was impracticable, owing to the circumstance that it was necessary to pulverise the ore, thereby unfitting it for exclusive use in the blast furnace.

The action of the smelting operation is such that not only is all the iron reduced, but also other elements, notably phosphorus, silicon, sulphur, carbon, and manganese; and it is only during disordered working, when oxide of iron is being slagged off, that any of the phosphorus existing in the mineral is removed. In the earlier days of iron smelting, when the furnaces used were very imperfect, it was possible to make excellent iron from ores which now give a very inferior product in the modern furnace, owing to this fact.

No method has as yet been discovered by which phosphorus and iron can be separated during smelting.

Up to the time of Bessemer's invention pig-iron was usually purified in the puddling process, the principle of which is the washing out of phosphide of iron by intimate contact with fused oxide of iron. Silicon and carbon are also removed, and wrought-iron of good quality can be made by this process from iron containing much phosphorus. Some of the silicon, and small quantities of phosphorus and carbon, are sometimes removed previous to puddling by the action of an air blast, and addition of oxide of iron, in the refinery, or 'running-out fire.'

The Henderson process has been very successful in removing the whole of the phosphorus rapidly during puddling; it consists in the addition of fluor-spar and titaniferous ore.

In the Bessemer process the carbon and silicon are rapidly and completely removed, but the phosphorus actually increases in quantity, or rather becomes concentrated, since the iron is to some extent oxidized, while the phosphorus remains unattacked. The siliceous lining of the converter forbids the existence of a basic slag, which is the condition necessary for its removal.

In the Siemens' process the same state of things exists, and since the greater proportion of the steel made in the world is the product of these two processes, it will be readily seen that the use of phosphoretic irons is very necessary, and in fact, is now a burning question since many articles formerly made of puddled iron, such as rails, are now made of steel. Iron ores suitable for puddled iron are consequently unfitted for the production of iron for steel-making.

The first process suggested for the rapid removal of phosphorus was that of Mr. Isaac Lowthian Bell, who proposed to wash the molten pig-iron with a large quantity of molten oxide of iron. By this means he succeeded in removing as much as 90 per cent. of the phosphorus.

Krupp's process consists in forming a thick coating of manganiferous iron ore on the bottom of a Pernot-Siemens furnace, and melting pig-iron thereon. It is stated that good results have been arrived at by this method.

The use of alkaline chlorides, fluorides, and other salts, have also been successful, likewise the action of chlorine gas in presence of an excess of carbon.

In 1872 Mr. G. J. Snelus pointed out that phosphorus could be eliminated by the maintenance of a basic slag in the Bessemer converter. Having noticed that certain kinds of magnesian limestone became indurated when fired hard, he lined up a vessel with such lime, and in it successfully dephosphorised Cleveland pig-iron containing about 1·50 per cent. of phosphorus.

Messrs. Thomas and Gilchrist have during the past year successfully worked out a process which is likely to be universally adopted. It is briefly, as follows:—

1st. A durable basic lining.

2nd. Additions of basic material.

3rd. Continuing the blast after the carbon has been fully oxidized, for the purpose of scorifying phosphorus.

Bricks of the following composition are made by firing at a temperature nearly equal to the melting point of platinum, and are very durable.

Silica	9·20
Lime	46·70
Magnesia	32·80
Oxide of iron, alumina, &c.	11·30
	100·00

A proper selection of the stone is all that is necessary; the presence of silica and alumina causes 'fritting,' and the bricks are very sound. Silicate of soda has been used, and Mr. E. Riley has made a lining by using petroleum or kindred oils, to render the lime plastic.

The additions of magnesian limestone, with or without mixture with oxide of iron, are made at the commencement of the process, resulting in the rapid removal of silicon; the carbon then commences to disappear, and when this has gone the phosphorus goes.

On the addition of spiegeleisen, the manganese, reacting on the phosphoric acid contained in the slag, causes a portion of the phosphorus to return to the metal. Hence the blown metal, with 0·076 per cent. of phosphorus, is converted into steel, with 0·177 per cent. by addition of spiegeleisen. This reaction was discovered by Mr. Stead, some years ago.

In the refining and puddling processes, as also in Bell's, the silicon and phosphorus are removed at the same time, and the carbon later, the elimination of phosphorus ceasing as soon as the carbon begins to go, whereas in the Thomas and Gilchrist process the carbon is all gone before the phosphorus commences to scorify. M. Pourcel argues from the foregoing that a highly silicious pig would be better than one low in silicon, but experience teaches that an excess of this element is very undesirable, owing to the fact that the blow is prolonged, an increased quantity of slag is made, the waste is greater, and the corrosive action of the silica on the lime lining is excessive. At present, however, the presence of silicon is necessary as a source of heat. Attempts have been made by Bell, Wilks, and Hollway to add carbon to the bath during blowing, as a source of heat. Hollway proposes to burn the flame within the vessel itself, by means of a separate range of tuyeres.

Some objections have been raised as to the commercial possibility of the manufacture of steel by such processes; these may be answered as follows:—

1st. Every kind of pig iron made is capable of treatment. Pigs high in silicon are objectionable, for the reasons previously stated.

2nd. Operations on a large scale are even more successful than experimental trials.

3rd. The waste is found to be 17 to 18 per cent., only 2 per cent. higher than in the ordinary Bessemer process. The amount of slag made is from 3½ to 5 cwt. per ton of pig iron used. The after-blowing is not a source of waste, inasmuch as that the iron does not commence to oxidise, until practically the whole of the carbon *and phosphorus* are burnt out.

4th. The corrosive action on the lining is greater than in the ordinary Bessemer process, but when blowing iron low in silicon the lining answers well.

5th. It has been said that the result of the process will be uncertain. In practice this is not found to be the case; in 20 blows the phosphorus was found to range from 0·04 to 0·14 per cent., and the analysis of numerous samples proves the steel to be of excellent quality. In a few cases, however, when the blast was not continued long enough, as much as 0·2 per cent. has been found.

6th. The sources of extra cost may be summed up as follows:—

1. The slightly increased waste.
2. The labour necessary to deal with the extra slag.
3. The cost of the bassic additions.
4. The extra cost of linings.
5. The decreased output of the plant, it being necessary to blow smaller charges owing to the slag, and the risk of splashing; and also the time occupied in taking samples.
6. The smaller production of the blast furnace while smelting poor phosphoretic ores, than when smelting rich hæmatite ores. This, however, it is contended, is already considered in the price of such iron.

The margin between Cleveland and Bessemer pig iron is now about 10*s.* per ton, but when prices reach a normal state it will be more than this. There is, therefore, that sum to work upon, and it does not appear that the items mentioned will amount to even 7*s.* 6*d.* per ton.

As a set-off against the cost of the process may be considered the fact that enormous deposits of cheap iron ore, now worthless for steel making, will be utilised, and that existing works will prolong their lives, especially those within easy reach of coal and ironstone.

It has been gravely asserted that steel made by any of the processes described cannot be of equal quality to that made from pure iron. This is simply an assertion not based on fact. Steel of good chemical composition, sound and clean, is as good as any other of the same composition, irrespective of how, where, or from what it is made It appears to be every day more and more probable that Bessemer and Siemens steel will gradually replace the finer qualities, now made by very expensive processes.

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4. *A New Process in Metallurgy.* *By* John Hollway.

The theory of this process has been developed from known principles, aided by experimental work undertaken for the purpose of investigating the action of rapid oxidation upon pyritous substances, with a view to their metallurgic treatment upon a large scale. Before these experiments were made, metallurgists had not realised the fact that pyrites and other sulphides (even with the addition of a considerable proportion of incombustible materials) can be decomposed and fused by the heat developed in the oxidation which takes place whenever air is rapidly brought into contact with an excess of molten sulphides. When this is effected by introducing air under pressure through apertures of a few millimetres in diameter in the bottom of a hearth upon which the molten sulphides lie, the results produced are very remarkable. Thus when cupreous pyrites was so treated, a true combustion of the more oxidisable constituents took place, flame and incandescence resulted, and the decomposition was effected with great rapidity.

It was primarily surmised that in this manner, neglecting the influence of mass, the elements would be burnt in the regular order of their relative affinities for oxygen, and that the second atom of sulphur in iron pyrites, which can be expelled by fusion, would escape oxidation in the molten bath and be volatilised in the current of sulphurous acid and nitrogen emerging from the surface of the molten liquid. The more volatile oxides and sulphides in the material operated upon, such as those of arsenic, antimony, lead, and zinc would volatilise with this freed sulphur, and condense partly before the latter, though more or less contaminating that product. If the oxidation be arrested at a point determinable by practice, calculation, or some marked change in the spectrum, two products of different specific gravity will be obtained, namely a slag of silicate of iron, lime, alumina,

&c., containing the iron protoxide resulting from the oxidation of the iron sulphide, combined as silicate with the siliceous fluxing materials present in the bath; and underneath this, the regulus or remaining unburnt sulphides, containing in an approximately known state of concentration the more valuable metals derived from the metalliferous substances operated upon. It was, however, necessary for the practical application of the theory that sufficient heat should be developed during the combustion of the iron, zinc, or other less valuable sulphides to keep the materials molten during the operation. The temperatures of combustion of various sulphides, calculated from known data, approached the maximum temperature attainable by the combustion of coal, and this inspired a considerable amount of confidence. In the case of iron pyrites these calculations are only rough approximations, as the latent heat of sulphur vapour is not known. It was found that when thus treating cupreous pyrites, the order in which the elements became oxidised was as follows:—

1. Zinc and iron.
2. Sulphur.
3. Lead and copper.

The above reactions find a parallel in the elimination of the metalloids from cast iron by Bessemer's process, in which silicon and carbon and then phosphorus and manganese are successively burnt out of the crude metal. Parallel analogies also exist between the process of puddling and English copper smelting; where the oxidation proceeds but slowly, and the necessary heat is obtained by the burning of coal.

The foregoing conclusions have been verified experimentally; full particulars thereof will be found in papers brought before the Society of Arts, February 12 and April 30 of this year.

The spectroscopic observations taken by Dr. W. M. Watts during the course of these experiments were valuable and interesting, and I am indebted to him for the following information:—

In the experiments at Penistone two spectra were observed; the first, that given by the flame from the charging door of the cupola in which the pyrites was melted; the second, produced by the blast of air through the molten protosulphide in the converter. The cupola-spectrum was shown by direct comparison with the spectrum of a flame coloured by lead chlorate to be mainly due to oxide of lead, but contained besides some few of the lines which appear to be proper to the converter-spectrum. Analysis showed that the lead present in the ore was almost entirely volatalised during the preliminary melting of the ore, the molten protosulphide charged into the converter containing only 0·8 per cent. lead. The converter flame gives a brilliant spectrum extending from the lithium line somewhat beyond the thallium line, which is usually present. Its most marked feature is the presence of four bright red lines about equally spaced between the sodium and lithium lines. Their wave lengths, as far as at present known, are approximately 5,999, 6,151, 6,320, and 6,466, besides a fainter line at 6,110. These lines are not those of any known spectrum. The way in which the flame is obtained suggests the theory that they are sulphur lines. When sulphur is burned in air or oxygen the spectrum obtained is entirely continuous, and even if air be bubbled through boiling sulphur no lines are obtained. Two spectra of sulphur obtained by the electric discharge through a vacuum tube containing vapour of sulphur have been described, but neither contains these four red lines. The spark with a Leyden jar in a current of sulphur dioxide at the ordinary pressure yields a spectrum (at present under investigation) apparently not previously described, in which, however, the red lines are altogether different from those of the converter-spectrum. The constancy with which these four red lines are associated together seems to preclude the possibility of their being due to different substances, otherwise the most refrangible line might be due to lead. No lines of copper were observed except in the fourth experiment, in which all the lines except those of sodium disappeared about six minutes before the turn-down. When in this experiment, towards the end of the blow, the subsulphide of copper began to burn, a splendid emerald green flame suddenly appeared, and all the lines except those of

copper and sodium left the spectrum. During the last few minutes of the blow the mouth of the converter was dull and without flame, the sulphur and oxidisable matter having been burnt out.

The principal cost of plant will be for the blast. Where sufficient water-power is available, a plant capable of treating 15,000 tons of pyrites annually could be erected at a cost of about 1,500*l*. Where, however, water-power is not available, steam boilers will be requisite, and the additional cost for plant may be 500*l*., or perhaps 1,000*l*.

With regard to the furnace, it is proposed to make the hearth, or rather crucible, of siliceous, aluminous, or refractory carbonaceous material. A sufficiently large proportion of siliceous flux in the furnace charge will greatly mitigate the action of the resulting iron protoxide upon the silica of the lining. Aluminous shrunk bricks may answer still better. It might even be found convenient to allow considerable corrosion to the lining to take place, if the converting hearth is of such form, and the materials are of such a nature, that it can be readily and economically renewed.

It may be also advantageous to run the regulus and slag, after the desired concentration has been effected, directly on to the hearth of a reverberatory furnace, where they can be kept molten by external heat, and where a more perfect separation of the one from the other may be effected. In such a furnace the final oxidation of the rich regulus would probably be most conveniently effected, although it is of course possible to produce metallic copper from the regulus by the transmission of air currents in a specially constructed furnace.

Not only would antimony, lead, zinc, copper, nickel, silver, and other valuable metals be extracted from the sulphides that contain them, but also from the incombustible fluxing materials that are added to the charge, and the extraction of the copper, and silver, and gold will probably be more complete than by any other known process. In countries where cupreous siliceous schists and sandstones abound, the use of these as siliceous fluxes would partially, if not wholly, compensate for the loss of copper in the slag. Thus, by using 0·5 ton of such material, containing 0·5 per cent. of copper for each ton of the sulphuretted ore, the whole of the copper could be recovered from the latter, assuming the slag to contain even as much as 0·2 per cent. of that metal.

The crude sulphur may be freed from the accompanying sulphide of arsenic by boiling it with milk of lime, and from the metallic oxides and sulphides with which it is contaminated by distillation; or purification by bisulphide of carbon might be resorted to. The sulphurous acid can be oxidised in chambers to sulphuric acid, either with or without previous liquefaction.

This process, on account of its simplicity and economy, may reasonably be expected, not only to take the place of the ordinary smelting, but also of many of the wet processes now in use.

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5. *A Lecture Experiment in Illustration of the Hollway Process of Smelting Sulphide Ores.* *By* Alfred H. Allen, *F.C.S.*

By causing oxygen gas to bubble through molten antimony sulphide contained in a V-shaped piece of combustion-tube, combustion takes place with such rise of temperature as to soften the glass, while a sublimate is obtained of antimonious oxide, and sulphurous acid gas is evolved. The sublimate is collected in an empty globe, and the sulphurous acid is absorbed by passing it into a large vessel containing lumps of wood-charcoal. At the conclusion of the experiment the contents of the combustion-tube may be poured out, when a button of metallic antimony free from sulphur is obtained.

By passing oxygen over lumps of pyrites contained in a heated combustion-tube, vivid combustion takes place, much free sulphur sublimes, and sulphurous acid gas is obtained and absorbed as before described.

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6. *Lead Fume, with a Description of a New Process of Fume Condensing.* By A. French.

1. The great loss of lead, and sometimes silver, by volatilisation induced Messrs. Wilson and myself to investigate the physical nature and deportment of metallic fumes as they exist in the furnace and in the flues.

2. The following is a classification of the various methods of condensing:—

(*a*) Deposition by its own gravity in long flues, with or without the addition of settling chambers.

(*b*) Filtering through porous materials, such as coke, brushwood, or coarsely woven fabrics.

(*c*) The use of water, either in the form of steam or in spray projected across the flue current.

(*d*) Processes based on the inverse of the preceding principle, viz., passing the lead smoke under and through water in a more or less comminuted condition.

3. We made experiments to prove the efficacy of each of those classes. The microscopic aspect of the fume was taken in the nascent stage, and after it had cooled and been exposed to friction in the flues. The fume taken from the interior of the lead flame forms a continuous film on a glass plate, that taken after it has assumed the condition of a white vapour, is granular, and consists chiefly of small isolated round particles.

4. We studied the chemical character of lead fume with analyses, and the influence of lead and zinc in promoting the volatilisation of silver.

5. Cooling and friction hasten the deposition of fume in flues. A good arrangement of flues is described.

6. We give a description of the filtering methods, with results of some experiments.

7. We also state the results of a condenser worked at the Wanlockhead Lead Works on the shower-bath principle. This apparatus was highly eulogised in the descriptive catalogue of the Exhibition of 1851; since then the company have doubled the quantity of lead saved, by supplementing a long flue, of one mile, to the condenser.

8. We describe the fourth class of condensers. The requisite conditions to obtain good condensation are to minutely subdivide the smoke current under water, and at the same time use means to neutralise the surface tension of the bubbles; those conditions are obtained by passing the smoke through a series of wire gauge diaphragms set close together and submerged in water to a depth of seven inches.

9. The paper concludes with a description of a new process and apparatus on the foregoing principle, assays of smoke before entering and after leaving the condenser, and general results.

SATURDAY, AUGUST 23, 1879.

The Section did not meet.

MONDAY, AUGUST 25, 1879.

The following Papers were read:—

1. *On the Constitution of Aluminic Compounds.* *By* Professor ODLING, *F.R.S.*

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2. *On the Presence of Nitrogen in Steel.* *By* A. H. ALLEN, *F.C.S.*

The author made some preliminary experiments on this subject in 1872, but has only recently obtained any definite results. The method adopted has been to dissolve the steel in hydrochloric acid, by which means any combined nitrogen may be presumed to be converted into ammonia. The solution obtained was then distilled with excess of lime, and the distillate examined for ammonia by Nessler's method. The employment of this extremely delicate test enabled the author to operate on a much smaller quantity of steel than was employed by previous investigators. Very special precautions were taken to obtain the hydrochloric acid and other materials free from any trace of ammonia or nitrous compounds, and the air was entirely expelled from the apparatus before commencing the operation. The hydrogen evolved was freed from any traces of ammonia by passing it through a tube filled with glass beads moistened with hydrochloric acid. It was proved by blank experiments that no source of ammonia existed in the reagents or apparatus. When absolutely pure materials were used, and every precaution taken to get rid of the contained air and other sources of error, the addition of Nessler's solution to the liquid obtained on distilling with lime caused a very marked yellowish-brown colouration. On comparing the tint produced with that yielded by a dilute solution of ammonium chloride of known strength, results were arrived at representing the proportions of nitrogen present in various typical specimens of steel. As the results obtained from steels of different kinds varied greatly, it cannot be assumed that there was a constant source of error in the mode of manipulation; while as the same samples gave substantially concordant results on repeating the experiment, the figures obtained were not the result of accident, but were true expressions of the proportions of nitrogen present.

In order to obtain ammonia in quantity sufficient for its recognition by other reactions than that with Nessler's test, the following plan was employed:—Steam, generated by boiling water in a flask, was passed over a considerable quantity of steel borings contained in a combustion tube, which was bent beyond the furnace, and prolonged so as to form the inner tube of a Liebig's condenser. To the further end a tube filled with glass beads and furnished with a glass stopcock was attached. A rapid current of steam was driven through the apparatus for a considerable time to expel every trace of air. On condensing the steam it was found free from any trace of ammonia. The steel borings were then heated to redness by a combustion furnace, and a rapid current of water passed through the condenser. The condensed steam, when tested by Nessler's solution, was found to contain abundance of ammonia, which did not diminish in amount till the borings were almost entirely oxidised. On redistilling the condensed steam, a distillate was obtained having a distinctly alkaline reaction to litmus paper, and on treating it with hydrochloric acid and platinic chloride a sensible amount of yellow precipitate was obtained, having the characteristic crystalline form of ammonium chloroplatinate. The amount found was larger than could possibly have been produced had the whole of the nitrogen of any residual trace of air been converted into ammonia. The author regards the results now recorded as preliminary merely, and proposes to extend the research to various classes of steel and iron, and

especially to such specimens as have been found to possess anomalous characters. Of these characters the evolution of ammonia from freshly fractured surfaces is among the most striking.

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3. *Colour Tests for the Estimation of Sulphur and Phosphorus in Iron or Steel.* *By* A. Vernon Harcourt, *M.A., F.R.S., Lee's Reader in Chemistry at Christ Church, Oxford.*

A weighed portion of finely divided iron or steel is treated in a flask with diluted sulphuric acid (previously boiled to expel air), with the addition of a lump of pure zinc. The sulphur contained in the iron is evolved as sulphuretted hydrogen, which, passing into a foot-glass containing lead solution, colours the latter. The phosphorus is evolved as phosphoretted hydrogen, which passes through the lead solution into a second foot-glass containing a dilute solution of silver nitrate. The flask is heated gradually to boiling, and then the depth of colour in the two foot-glasses is compared with two sets of standards.

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4. *Some Experiments with the Voltaic Induction Balance.* *By* W. Chandler Roberts, *F.R.S., Chemist of the Mint.*

The author stated that this instrument, which we owe to Professor Hughes, the discoverer of the microphone, appeared to be one of no ordinary importance; and although the experiments about to be described were far from complete, they possessed sufficient interest to warrant their being submitted to the Section. He then described and exhibited Professor Hughes' instrument, showing the extreme delicacy by which changes in the indueed current were indicated by the microphone and telephone.

The relative values of different metals, as indicated by the induction balance, do not accord with the values usually accepted as representing the relative conductivities of the respective metals; and this being the case, Mr. Roberts had ascertained what relation the indications given by alloys when under the influence of the induced current bear to their electric conductivities.

The experiments on a comprehensive series of alloys proved that, in the case of alloys of certain metals, the induced current curves closely resembled those representing electric conductivity; but that in certain other cases the induced current revealed differences that had hitherto escaped observation. As an example, Mr. Roberts alluded to the curve of the copper-tin alloys, in which there is a sudden break between the points, representing two alloys, which only vary by a single equivalent, or by 6·4 per cent. of copper. These two alloys are widely different in colour, fracture, density, and structure, and the induction balance at once afforded evidence of a marked difference not shown in Matthiessen's curve of electric conductivity.

It is known that certain metals when alloyed undergo a molecular change, and that an allotropic condition may in some cases be induced by alloying a metal with a small quantity of another, facts which will doubtless receive careful examination from those who are pointing to the non-elementary character of certain metals.

Mr. Roberts then referred to the question of applying the induction balance to the assay of metals. In the case of gold-silver alloys the instrument will show the presence of less than 2 grains of gold in the pound of silver. On the other hand, the silver-copper alloys used for coinage are situated at the flat portion of the curve, so that it is impossible to detect even considerable differences in their composition, and these alloys, which are very peculiar to their nature, appear to be greatly affected by annealing. More hopeful results were obtained with the gold-copper alloys, and Mr. Roberts demenstrated a difference of 1 per cent. in the standard of two gold discs, which, though far short of the existing method of assay in delicacy, appeared to afford grounds for the belief that very accurate results will ultimately be obtained.

5. *A Historical Sketch of the various Vapour Density Methods.* By James T. Brown, *F.C.S.*

Although Southern in 1803 made some very careful experiments to determine how much water was required to furnish one cubic foot of steam at various pressures, still the foundation of vapour-density methods was laid by Gay-Lussac. He, in 1811, started on the correct basis of accurate work when he heated a weighed quantity of substance over mercury in a graduated vessel. In 1822, Cagniard de la Tour determined the combined effects of heat and pressure on certain volatile liquids, but as his results were on the question of maximum vapour-density, they hardly enter the domain of the present sketch. In the same year, Despretz, who gave no drawing, and only a very imperfect description of his apparatus, published a method in which he used a 9-litre exhausted globe, and made his determinations at atmospheric temperatures, employing only a small quantity of substance. In 1826, Dumas, wishing to operate on substances which attack mercury, worked out and published his well-known method, in which the volume is definite, but the amount of substance required to fill that volume with vapour has to be subsequently determined.

In 1833, Mitscherlich proposed using tubes, sealed at one end, and drawn to a neck at the other, instead of bulbs, and gave details and drawings of the apparatus for heating them; but Dumas, two years later, objected to the proposed alteration in his method, for he wrote:—'We must then leave to this operation all its simplicity to make it essentially practical, and such, in fact, that with an ordinary cast-iron pot, and some pieces of iron wire, we can perform it. This is what I have done from the first, and what I persist in doing, my aim never having been to make a piece of apparatus for the cupboard of the physicist, but to give chemists a simple and eminently practical, and yet exact process. After all *they* are the only ones to be considered.' Deville and Troost, however, in 1860, in referring to that same apparatus, called it, 'La méthode si élégante de M. Mitscherlich.'

Bineau, in 1838, published an elaborate paper, but, unfortunately, without any drawings, for when we read the following paragraph—'The bodies on which I have worked have been volatilised, sometimes by the aid of heat, by following the process of Dumas or that of Gay-Lussac, sometimes without elevation of temperature, by working in the barometric vacuum, or by allowing the vaporisation to take place in dry air or hydrogen'—we cannot but feel that an enormous amount of valuable work has been lost for want of details. In 1844, we find Cahours, as well as Bineau, at work at the same subject. In 1846, the latter repeated the experiments of Despretz with slight modifications, but called attention to the fact that the result was seriously affected by very small errors in reading off the mercurial column.

In 1849, Regnault used an apparatus very similar to that of Mitscherlich, but arranged the tube supports so that the two could be withdrawn simultaneously; he also dispensed with sealing the tube containing air, by providing it with a stop-cock. Bineau, in 1859, in order to operate at high temperatures, coated the glass tubes with clay, and heated them in a sand-bath.

Regnault, in 1861, to obtain the same result, used iron tubes, and to ensure uniformity of temperature, heated them in a cast-iron tube, which was made to revolve over gas-burners. The tube which served as air-thermometer, was furnished with a stop-cock, but that containing the substance only terminated in a small aperture, and was not closed, as a sufficient quantity was introduced before the heating to allow it to be taken for granted that during the experiment there was no residual air. Another method of Regnault's was to have two iron bottles, of as nearly as possible the same size, cast in one piece. In one of these the substance was placed, and in the other a small quantity of mercury. The necks were then partially closed by loose stoppers, and the system was heated in a muffle. After heating, it was withdrawn, and allowed to cool, and the quantities remaining in the bottles were determined by suitable means.

Grabowski, in 1866, did much to shorten the Dumas calculation, while he

allowed the method to retain all its accuracy and simplicity, when he proposed to heat a bulb containing air in the same bath, and of the same size, as that containing the substance. After being heated, the two bulbs were then sealed at the same temperature. Bunsen, in 1867, employed an air-bath, similar in principle to those of Mitscherlich and Regnault, but heated it by a very elaborate arrangement of gas burners. He also simplified the calculation by taking care that *all* the tubes were of *exactly* the same weight and same size. He did not seal the tubes, but closed them by glass caps, lined with india-rubber and fitted with glass plugs. Dumas, in cases where the vapour rendered the outlet difficult to seal, used globes fitted with ground stoppers.

For the Dumas process at high temperatures, Deville and Troost, in 1860, recommended heating the bulb in a specially constructed furnace, in the vapours of substances having high but definite boiling-points, such as mercury, sulphur, zinc, or cadmium. For temperatures above the boiling-point of sulphur, they used porcelain globes. For temperatures up to that point, the smaller and more compact apparatus devised by Greville Williams answers admirably.

Roscoe, last year, in determining the vapour-densities of the chlorides of lead and thallium, used porcelain globes of 300 c.c. capacity, heated in a muffle, but determined the temperature by the method of specific heat, a large piece of platinum being employed for the purpose, and checked the result by the simultaneous determination of the vapour density of mercury.

For working at a reduced pressure, Regnault proposed partially exhausting the bulb by means of an air-pump during the experiment; when the desired temperature was reached, it was sealed off at a point where the neck had been narrowed to a convenient size. In 1876, Habermann gave a complete diagram of the apparatus, replacing the air-pump by a Bunsen pump; but although he made no alteration in the method, still it was referred to by Sommaruga as Habermann's.

Various experiments had been performed on vapours mixed with air, but the main point in Playfair and Wanklyn's method (1861) consisted in stopping the supply of vapour before the bath in which the bulb was being heated had attained its maximum temperature.

Natanson, in 1855, in order to use the Gay-Lussac method up to a temperature of 300°, heated the upper part of the tube by means of charcoal in a cylindrical furnace, and determined the temperature by thermometers suspended in the air-space between the graduated tube and the inner tube of the heating apparatus. In correcting for the tension of mercury-vapour he used Avogadro's tables.

Greville Williams, in 1857, wishing to make some determinations at varying pressures, devised the following method:—The graduated tube is, after it has been filled and the bulb has been inserted, screwed by means of a nipple cemented to the bottom into an orifice in the top of a small metallic cistern into a second orifice in which a long open glass tube is fitted. Into this tube mercury is poured until the required pressure is obtained. To reduce the pressure the excess of mercury is allowed to escape by a tap in the side of the cistern. The whole is heated in a water- or oil-bath.

In Regnault's apparatus for the same purpose, the two tubes are fastened to the bottom of the water-bath and are connected by a T piece, which is closed by a three-way cock of special construction.

For determinations up to 150° Greville Williams's compact modification consists in replacing the large vessel of mercury, and the open glass cylinder by a cylinder closed and rounded at the lower extremity, so as to resemble a large test-tube. This is then filled to a depth of 50–60 m. m. with mercury, and above that with water or oil to a convenient height. The graduated tube is filled and the bulb inserted over the mercurial trough; it is then immersed in the large tube by means of a rod having at the end a small cup containing mercury. The large tube may be supported on wire gauze and heated by a Bunsen burner, or may be placed in a shallow oil-bath.

Schiff, in 1862, proposed steadying and manipulating the graduated tube by means of a loaded handle, which was secured to its upper extremity by spring clips.

Grabowski, in 1866, replaced the charcoal furnace of Natanson by a very much

neater air-bath heated by gas, but the chief merit in his method is that a tube containing air is heated by the side of that containing the substance. As soon as the substance is all converted into vapour, air is passed up into the second tube until it occupies as nearly as possible the same volume as the vapour. After the operation the air is measured at atmospheric pressure and temperature.

Croullebois, in 1874, reverted to Bineau's method of using a large globe with a long tube, but took the precaution to heat the upper portion in a water-bath. Deville, however, criticised his method rather severely, and pointed out that it was an unwieldy apparatus to manipulate.

In 1868, Hofmann, in modifying the Gay-Lussac method, while he adopted the long tube which had been previously used by Bineau, Playfair and Wanklyn, and Grabowski, introduced such an important alteration into the apparatus that it is not spoken of as his modification but as his method. Instead of heating the substance-tube by a water-, oil-, or air-bath, he simply enclosed it in a slightly larger mantle tube, and passed the vapour of a liquid of definite boiling-point through the intervening space, selecting the liquid according to the temperature required. By this means he not only rendered the apparatus much more compact, but he maintained a steady temperature with the greatest ease. Wichelhaus, in 1870, anxious to avoid the uncertainty introduced by the doubt as to the temperature of the column of mercury between the bottom of the outer tube and the trough, dispensed with the latter by fixing to the lower extremity of the substance-tube an inverted siphon containing mercury. Then, by lengthening and suitably enlarging the lower extremity of the outer tube, the whole of the inner one can be surrounded by vapour.

Grabowski, in 1875, in order to obtain a high temperature, employed the vapour of naphthalene as the heating medium in using Hofmann's apparatus; but Engler, in the following year, finding that the stoppage of the tubes from the solidification of the condensed hydrocarbon was troublesome, proposed to obviate the difficulty in the following manner:—He fixed to the lower end of the outer tube a metal socket provided with a short side-tube similar to those used for heating funnels. Then, by boiling the heating medium in this tube and allowing the vapour to cohobate in the space between the two glass tubes, he dispensed with all the arrangement of flask, tubes, and condenser.

Hofmann at the same time made several modifications in his apparatus:—

(1.) He proposed heating the whole length of the inner tube by making the outer one long enough to enter the mercury in the trough, and provided for the escape of the condensed liquid and excess of steam by having a small side-tube affixed a short distance above the level of the mercury.

(2.) Finding that graduated tubes were very liable to crack, he proposed using plain ones in the following manner:—In the bottom of the mercurial trough he placed a piece of sheet india-rubber attached to an iron plate and provided with a groove on its upper surface; the iron plate was furnished with a handle. During the heating the inner tube stood over the groove to allow of the escape of the mercury. When the level became stationary, communication with the mercury in the trough was cut off by shifting the india-rubber disc until the inner tube rested on the flat surface. The height of the column in the inner tube was then noted by means of a cathetometer; the outer tube was then removed, and a gummed label attached to the inner one to indicate the mercury level. After cooling, the volume of the vapour is determined from direct measurement.

(3.) In order to avoid the cracking of the tubes in cases where liquids of high boiling-point were used, he proposed connecting the lower end of the outer tube with the inner one by a cork, through which two tubes leading to the flask or boiler passed. One of them led below the liquid, while the other, which was provided with a stop-cock, reached only just below the cork. If this stop-cock be closed while the liquid is being heated a portion of it is forced up the space between the two glass tubes, and thus the mercurial column is heated more gradually. When the liquid reaches the boiling point the stop-cock is opened and the circulation of the steam proceeds as usual. The upper part of the outer tube must be sufficiently elongated or provided with a small tube leading to a condenser.

Brühl proposed working the Hofmann method at a very low pressure by employing a tube 1·5 metrès long with only a small quantity of substance, and was therefore able to make determinations at temperatures far below its boiling point. He also made the following suggestions:—

1. In order to eliminate the troublesome element of the tension of mercury-vapour (without using two tubes, as Grabowski did), heat the column to the required temperature, note its height, then allow it to cool; introduce the substance, and heat again to the *same* temperature till the height is constant. To ensure uniformity of level in the bath keep it full to overflowing.

2. Before the first reading of the mercurial column, a small piece of thin glass is passed up to liberate any air that may be contained in the mercury.

3. To make a mark on the tube a little above the vacuum mercury level, and then only to calibrate about 150 m.m. down from that point; then, to find the total volume, add the variable volume below the mark to the fixed volume above the mark.

Muir and Suguira, in 1877, finding that sometimes the weight of the inner tube caused the groove in the india-rubber disc to so far close as to prevent the escape of the mercury while heating the substance, used a plain india-rubber disc, which was fastened to the bottom of the trough, a disc of cork intervening. Communication between the mercury in the tube and that in the trough was maintained by means of a short piece of glass tubing bent at right angles. A second tube, long enough to stand slightly above the level of the mercury in the trough, served to carry off from the space between the two tubes the condensed liquid and excess of vapour. They adopted Hofmann's original method of passing the steam in at the top of the outer tube, but used a small tube passing through a perforated cork in preference to one fused to the end.

Brühl has this year proved, by most carefully conducted experiments, that the Hofmann method cannot be used above 220°, owing to the great and rapidly increasing vapour-tension of mercury; but has omitted the grave objection to his own method. Playfair and Wanklyn called attention in 1861 to the fact that Bineau, in 1846, pointed out that in vapour-density methods, at very reduced pressures, slight errors in the readings of the mercurial level introduce very serious errors into the result.

In the Overflow methods, which are in reality modifications of the Gay-Lussac, seeing that they are performed with known weights of substance, the first name is Hofmann, who in 1860 gave a very meagre description of his apparatus, when he wrote that he used an U tube heated in a paraffin bath, and estimated the volume of the vapour by the mercury expelled. Werthein, in 1862–64, in his papers on Conün, gave full details of his method, in which he used two tubes suspended side by side in a flask.

Watts, in 1867, employed a globe with a ground neck, into which an outlet tube, reaching nearly to the bottom of the globe was accurately fitted. The globe being filled with mercury, and the substance introduced, the quantity of mercury expelled on heating served as a basis for calculating the volume occupied by the vapour. Victor Meyer, in 1876, introduced two very important alterations, he avoided the vapour-tension of mercury by using fusible metal, and placed the outlet at the bottom of the bulb. His experiments at that time were all made in the vapour of boiling sulphur, but Graebe, last year, wishing to employ a higher temperature, used phosphorus pentasulphide, which boils at 530°.

Frerichs, in 1876, used mercury in an apparatus similar in principle to that of Watts, but employed an inverted flask, and brought the exit-tube, which was furnished with an inverted siphon, through a suitable outlet in the bottom of the bath.

Goldschmiedt and Ciamician, in 1877, used mercury with the simpler bulb of Victor Meyer, but added a small side-tube to the outlet, so that the mercury expelled could be weighed from time to time during the heating. Victor Meyer, in the same year, modified the shape of the bulb, but heated it in a tube similar to that employed by Greville Williams in the Gay-Lussac determinations, but of sufficient length for the upper part of the tube to serve as condenser.

Pfaundler's method, of which a preliminary notice appeared in 1870, but which was not brought prominently forward till this year, is based on the increased tension of the air in an elongated bulb produced by heating after the introduction of the substance, as compared with a similar determination of air in a bulb of the same size. A very short description appeared in 1874 of a method devised by Dulong, which is based on the same principle.

Last year Hofmann proposed two methods; in one of these, he heated the weighed substance over mercury in the closed limb of an U tube, and marked the level of the mercury in the open limb by sliding a pointed tube through a loosely-fitting perforated cork until it touched the surface. When the apparatus was cool, the volume of the vapour was calculated from the weight of mercury required to restore the level to that same point. The other consisted in introducing into a tube a small but weighed quantity of substance, then exhausting it, and sealing it, and heating in a jacketed tube. At the required temperature, the point of the glass tube is opened to allow air to enter, and then at once sealed again. After cooling, the point is opened under mercury or water, and the volume occupied by the vapour is measured.

In Meyer's method, which is so recent and well known as not to require any explanation, the principle is that of Pfaundler's, but by having the neck elongated, and the outlet as a side-tube, the substance is introduced *after* the bulb is heated to the required temperature, and by allowing the air expelled by the vapour free egress into a graduated tube, it can be measured under atmospheric conditions. It is, therefore, so simple that the operation only requires a very short time from first to last.

In this sketch I have purposely kept off the very enticing ground of *formulæ*, as they, of themselves, open up so wide a field that they could not be dove-tailed into the history of the subject, which from *any* point of view is interesting.

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6. *Note on the Vapour Densities of Ferrous Chloride and Iodide of Potassium.* *By* J. Alfred Wanklyn.

The recent observations made by the method of Victor Meyer admit of explanation on the supposition that ferrous chloride, when strongly heated in an iron vessel, is resolved into $Fe_2\,Cl_2$, and that the iodide of potassium, under like conditions, gives $K_2 + Fe_2\,I_2$.

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7. *Note on the Constitution of Isocyanopropionic Acid.* *By* J. Alfred Wanklyn.

In the 'Philosophical Magazine' for last May, Mr. Cooper and myself described an acid to which we gave the name isocyanopropionic acid.

The acid had been prepared by the oxidation of wool by means of permanganate of potash and caustic potash, and had the formula $C_4H_5NO_2$.

We have acted upon the acid by means of caustic potash at 200° C., and thereby obtained ethylamine and oxalate of potash, thus:—

$$C_4H_5NO_2 + 2KHO = C_2K_2O_4 + C_2H_7N.$$

This reaction points to the following structure:—

$$\begin{array}{l} HO\,CO \\ \quad\;\; C \\ \quad\;\; \vdots \\ \quad\;\; N \\ \quad\;\; \vdots \\ \quad\;\; CH \\ \quad\;\; CH_3, \end{array}$$

and the acid should therefore be called ethylene-isocyan oxalic acid.

It is no doubt the representative of a numerous class of acids, characterised

by furnishing oxalic acid and an organic base on treatment with alkali at high temperatures. It is an exceedingly interesting fact that oxidation in alkaline solutions should give oxalic acid in the case of non-nitrogenous organic bodies, and a nitrogenous oxalic acid in the case of nitrogenous organic bodies.

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8. *Physical Constants of Liquid Acetylene and Hydrochloric Acid.* *By* G. ANSDELL.

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9. *The Action of Ammoniacal Salts on Metallic Sulphides.* *By* M. DE CLERMONT.

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10. *On the Chemical Composition of a Nodule of Ozokerite found at Kinghorn-ness.* *By* W. IVISON MACADAM, *F.C.S., &c., Lecturer on Chemistry, Edinburgh.*

The nodule to which this paper refers was discovered at Kinghorn-ness during the excavations rendered necessary by the fortifications at present being raised for the defence of the Firth of Forth.

The material was enclosed in a nest or nodule, and was found at a depth of 15 feet from the surface of the ground and embedded 5 feet in hard trap rock.

The rock in which the nodule was obtained was sound, no crack or fissure being observable for several feet round the nest. At a point some distance below the nodule the section shows a series of small veins or fissures running through the rock in various directions and averaging $\frac{3}{4}$ of an inch in breadth. The analysis of this rock gave the following results calculated to percentages.

1. On treating the pulverised sample with hydric chloride (HCl) and subjecting the mixture to a prolonged low heat, it was found that 29·73 per cent of the substance dissolved in the acid. The detailed results of the analysis of this solution are as follows:—

	Per cent.
Ferric oxide (Fe_2O_3)	11·45
Aluminic oxide (Al_2O_3)	3·63
Calcic oxide (CaO)	3·70
Magnesic oxide (MgO)	0·37
Potassic oxide (K_2O)	0·13
Sodic oxide (Na_2O)	
Carbonic anhydride (CO_2)	8·17
Sulphuric anhydride (SO_3)	0·21
Silica from soluble silicates (SiO_2)	2·07
Total soluble in acids	29·73
Insoluble in acids, silicates, &c.	70·27
	100·00

2. The portion insoluble in acids was then fused with a flux, and the following results obtained from the after solution in acids:—

	Per cent.
Ferric oxide (Fe_2O_3)	9·92
Aluminic oxide (A_2lO_3)	5·36
Calcic oxide (CaO)	8·17
Magnesic oxide (MgO)	5.67
Silica from silicates, &c. (SiO_2)	41·12
Total from fused portion	70·24
Soluble in acids	29·73
	99·97

The rocks lying next to the trap were also analysed and gave results as stated below:—

1. *Soluble in Hydric Chloride* (HCl).

	No. 2. Rock above trap	No. 3. Rock below trap	No. 4. Same as No. 2, but nearer the surface of ground
Ferric oxide (Fe_2O_3)	21·37	31·48	15·78
Aluminic oxide (Al_2O_3)	4·06	4·59	7·92
Calcic oxide (CaO)	2·83	3.11	2·19
Magnesic oxide (MgO)	2·98	4·23	2·47
Potassic oxide (K_2O) } Sodic oxide (Na_2O)	0·98	0·82	1·48
Carbonic anhydride (CO_2)	5·19	6·01	4·62
Sulphuric anhydride (SO_3)	0·32	0·28	1·62
Sulphur (S)	0·13	0·16	1·17
Silica (SiO_2) from soluble silicates	2·08	2·23	3·95
Moisture	3·22	3·41	3·14
Total soluble in acid	43·16	56·32	44·34
Insoluble in acid	56·84	43·68	55·66
	100·00	100·00	100·00

2. *Matter insoluble in Hydric Chloride* (HCl), *fused with flux and treated with Acid.*

	No. 2. Rock above trap	No. 3. Rock below trap	No. 4. Same as No. 2, but nearer the surface of ground
Ferric oxide (Fe_2O_3)	5·28	4·84	7·04
Aluminic oxide (Al_2O_3)	3·48	4·12	7·76
Calcic oxide (CaO)	2·15	1·18	0·78
Magnesic oxide (MgO)	1·03	0·28	0·24
Silica (SiO_2) from silicates &c.	44·68	33·12	39·72
Total from fused portion	56·62	43·54	55·54
Soluble in acids	43·16	56·32	44·34
	99·78	99·86	99·88

The nodule when broken consisted of

1. An outer coating of hard rock;
2. An inner lining of calcite crystals; and
3. Centre nodule of bituminous matter.

When first brought to light, the calcite crystals were almost black in colour, due to a certain amount of the bituminous matter; but this slowly evaporated, and left the crystals pure white in colour. The analysis of these crystals of calcite yielded the following results:—

	Black crystals, containing bitumen	White crystals
Calcic carbonate ($CaCO_3$)	96·76	98·11
Ferrous carbonate ($FeCO_3$)	0·19	0·21
Magnesic carbonate ($MgCO_3$)	0·31	0·33
Silica (SiO_2)	1·06	1·22
Bituminous matter	1·68	0·13
	100·00	100·00

The lower veins or fissures were also calcite-lined, and contained within this coating the bituminous matter.

Besides the nodule found at Kinghorn-ness, another nodule of a similar character was obtained on the Island of Inchkeith, embedded in solid trap, ten feet from the surface, and a small spring of water on that island smells and tastes distinctly of paraffin products.

The Kinghorn-ness nodule has a distinct bituminous odour, is a lustrous black, amorphous, soft solid, easily cut with the nail and pliable between the fingers. The specific gravity is 970 (water 1,000), so that the nodule floats upon water. It fuses at 176° F., and becomes solid on cooling. Experiments with the various solvents upon the bituminous material showed that water and ordinary acids had practically no action whatever. Alcohol, both hot and cold, had a very slight solvent power, but ether dissolved a considerable proportion, giving a brown solution, and turpentine readily acted upon the substance, yielding a deep brown-black solution. The ethereal liquid had a fine iridescent green colour when viewed by reflected light. The substance of the nodule readily burns when lighted, giving a strongly luminous flame.

The analysis of the contents of the nodule gave as follows:—

	Per cent.
Volatile organic matter	99·38
Ash or mineral matter	0·61
	99·99
Volatile gaseous matter given off below 212° F.	5·961

When distilled at a bright cherry-red heat, 26·57 grains being used, the results gave:—

		Grains
Volatile matter		15·93
Coke 10·64 grains	Fixed carbon	10·48
	Ash (mineral matter)	0·16
		26·57

These results, calculated to the percentage, give:—

		Per cent.
Volatile matter		59·955
Coke 40·041 per cent.	Fixed carbon	39·431
	Ash (mineral matter)	0·610
		99·996

The coke left behind after this treatment was a hard, black, shining, porous mass, and the ash obtained by incinerating it was pure white, and principally consisted of calcic carbonate ($CaCO_3$) and silica (SiO_2).

The material was afterwards submitted to destructive distillation at a black-red heat, when the substance was found to split up into six distinct parts—four dis-

tillates, a coke, and a volatile non-condensable gas. In this operation 58·29 grains were used, and yielded:—

	Grains
1st Distillate	5·65
2nd „	11·35
3rd „	21·33
4th „	14·72
Total volatile condensable products	53·05
Coke	2·28
Uncondensable gas	2·96
	58·29

Calculated to percentages, the results stand:—

	Per cent
1st Distillate	9·694
2nd „	19·471
3rd „	36·592
4th „	25·253
Volatile condensable products	91·010
Coke	3·911
Uncondensable gas	5·078
	99·999

When first heated the substance fused and frothed, and on the further application of heat gave the first distillate, which was of a gray colour, somewhat mobile, and had a disagreeable odour. The second distillate was black in colour, fully more mobile than the first distillate, and also possessed a most disagreeable odour. The third portion was more mobile than the second, had a yellow colour, and a marked paraffin odour. The fourth distillate was obtained after raising the heat, had a yellow-red colour, was liquid whilst hot, but turned solid on cooling, and had also a paraffin odour. The uncondensable gaseous matter readily burned on the application of a white light, gave a pale non-luminous flame, and possessed all the chemical properties of methane or marsh gas (CH_4). The carbon left in the retort added to the amount of uncondensable gas gives 8·989 per cent., and on calculating the uncondensable gas into ethylene or olefiant gas (C_2H_4), the result obtained is 8·886, or nearly identical. These results go far to show that the bituminous-like matter of the nodule consists of a member or members of the olefine (C_2H_4) series of organic compounds—a point which is further strengthened by the fact that the carbon and hydrogen in the original substance are contained therein in almost exactly the necessary proportions to form an olefine.

It is probable that the source of the contents of the nodule lies in one of the coal or shale beds abounding in the district, and that a low internal heat has distilled the material from its parent stratum. That the heat was low, or certainly not above a cherry-red, is certain, else the olefine would have been split up into a member of the methane or CH_4 group of organic substances, accompanied by a deposition of free carbon.

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11. *On Some Curious Concretion Balls derived from a Colliery Mineral Water.* By Thomas Andrews, *F.C.S.*

The water on which these observations were made was collected from the 'sump' of the Wortley Silkstone Colliery, a small pit situated near the 'Bassett' or 'outcrop' of the great Silkstone seam of coal; the samples being obtained during typical *dry* and *rainy* seasons. The water had percolated from the surface a distance of 35 yards, through strata, as indicated on the accompanying table.

The bottom layer in which the water lodged was the Silkstone seam of coal, here some 5 feet in thickness.

One noticeable feature of this water is, that it always gives an acid reaction with blue litmus paper.

Several analyses of this water made at various times indicate that the chief

mineral constituents of the water are, iron—calcium, magnesium, in the form of sulphates.

This water when heated quickly throws down a copious ochreous deposit. The deposit found in the engine boilers after having used the water in them for steam purposes was of the composition given below.

The boiler residue from which this sample was taken, consisted of an incrustation about *one inch* thick, which had adhered to the bottom of the boiler.

The incrustation was of a light reddish yellow colour in the bulk, it was very hard and tough, and not easily broken in pieces.

The iron work in connection with this colliery engine and boilers, in any way exposed to the action of either the acid water itself, or *the steam generated from it*, becomes corroded and partially dissolved. The most effectual remedy against this corrosive action and deposit, is that described in my letter to the *Chemical News*, June 15, 1877.

Analysis of Boiler Deposit, from Wortley Silkstone Colliery Boilers, September 15, 1875.

Moisture	6·85 per cent.
Combined water, organic matter, &c.	5·80 „ „
Silicious matter	1·80 „ „
Per-oxide or iron and alumina containing phosphoric acid 0·76 per cent.	6·10 „ „
Sulphate of lime	78·55 „ „
Magnesia	0·65 „ „
	99·75

Some curious balls of mineral matter are occasionally found in the feed tank of the colliery boilers, which are supplied with this water. The water is pumped up from the engine pond into a cylindrical feed tank, and is there heated by the exhaust steam from the engine playing on its surface (not blowing through it). The water in this feed tank has an average temperature of 164° F.

It sometimes happens that during the short space of even two or three weeks, great numbers of these balls are formed, varying in size from about three and a half inches in diameter to five-eighths of an inch diameter, and in weight from about one and a half pound to a quarter of an ounce.

The author has many of these in his possession. They are perfectly hard and compact when taken from the tank, and are no doubt formed from the deposit thrown down when the mineral water is heated.

The action of steam playing on the surface of the water probably causes circular eddies, and when a nucleus has thus once been formed, it is easy to conceive of the gradual formation and consolidation of these balls.

The author suggests that the conditions of formation of natural nodules of iron ore, pyrolusite, &c., may be similar to those observed by him in the foregoing cases.

The following is the analysis of the balls formed in the feed tank, from which it will be seen that they are quite different in composition to the residue deposited in the boilers, owing probably to the difference in the temperature between the feed tank and the boiler.

Analysis of a Concretion Ball, found in the Engine Feed Tank. Wortley Silkstone Colliery.

Moisture	2·30 per cent.
Loss on ignition, organic matter, &c., contains matters extracted by ether, 5·8 per cent.	24·40 „ „
Silica	1·80 „ „
Per-oxide of iron	62·86 „ „
Alumina	5·43 „ „
Phosphoric acid	2·81 „ „
Lime	0·40 „ „
Magnesia	trace
	100·00

They also differ in composition from concretions deposited at the pit bottom in the cold, which show only 47·71 per cent. of Fe_2O_3.

Observations made to ascertain the Temperature at which the deposit and turbidity take place.

Temperature at which Turbidity commences.		
	Dry Seasons	Wet Seasons
Average of Four Observations . . .	147°F.	160·4°F.

The action of this mineral water is destructive to all iron work with which it comes in contact. The amount of iron dissolved by samples of the water in the cold being as follows:—

July, 1868—7,000 fluid grains = 1 lb. of the water dissolved 1·85 grain of iron during one month.

Feb., 1876—3,500 fluid grains = $\frac{1}{2}$lb. of the water (collected during a *dry season*) dissolved 2·91 grains of iron in eight months.

July, 1876—3,500 fluid grains = $\frac{1}{2}$lb. of the water (collected during a dry season) dissolved 4·73 grains of iron in eight months.

Reaction of the water with litmus at the conclusion of these experiments only *faintly* acid.

Quantities of iron pyrites are found in the coal strata of this neighbourhood, and account for the large quantities of sulphates often found in these colliery waters.

The water during *flood seasons* required (as an average of five determinations) an addition of 10·48 grains of anhydrous Na_2O per gallon, before an alkaline reaction was obtainable, and during *dry seasons* (as an average of three determinations) an addition of 17·35 grains of anhydrous Na_2O per gallon. This amount of alkali does not all correspond to free acid, as the sulphate of iron would also neutralise soda.

Determinations of the total inorganic constituents were made at the dates and with the results as below.—Results in grains per gallon.

Date	Total amount of Inorganic Matters	
June 20, 1865	56·60	
October 12, 1867	66·60	
July 27, 1868	67·70	(Very dry season)
June 25, 1874	133·70	(Very dry season)
June 27, 1874	198·80	

The sulphates, a very important element in the composition of this water, were determined as per following results. An average of six estimations of the total sulphates (results calculated as SO_3), extending from 1865 to 1876, made during—

Dry seasons—giving 115·41 grains per gallon of SO_3.

An average of eight estimations, extending over the same period of time, but made during

Rainy seasons—gave 67·62 grains per gallon of SO_3.

A fact worthy of notice in course of these analyses is the steady and large increase in the amount of the sulphates, from the commencement of these observations in 1865 to 1876.

The same result is also noticeable on reference to the total amounts of inorganic matter, which show a great increase in quantity during the latter part of the time.

Now why this increase in the total sulphates and total matters in solution should take place, it is not easy to say. It may be owing to the fact of the increased length and area of the workings in the colliery, as undoubtedly there is more bulk of water to contend with now than formerly on this account; but why the mineral

matter in the water should have increased owing simply to this increase in quantity is not at first sight very clear.

It may be possible that the largely increased number, area and length of air-ways has a tendency to expose the water for a longer time to oxidising influences, and thus add to the percentage of sulphates, and this increased facility for oxidation no doubt also induces more rapid solution of the strata as the water slowly permeates through it.

The author hopes these few imperfect observations may not prove altogether uninteresting to those who take pleasure in the study of mineral waters.

TUESDAY, AUGUST 26, 1879.

The following Papers were read:—

1. *On some points in connection with Agricultural Chemistry.* *By* Dr. J. H. Gilbert, *F.R.S.*

Dr. Gilbert stated that in the experiments of Mr. Lawes and himself, conducted on the farm of Mr. Lawes, at Rothamsted, Herts, wheat had now been grown for thirty-six years in succession on the same land; barley for twenty-eight years in succession, oats for nine years, root crops for more than thirty years, beans for more than thirty years, and they had experimented on the mixed herbage of grass land for twenty-four years. They found minor distinctions in the manurial requirements of different plants of the same natural family, but very great distinctions in the requirements of plants of different natural families. The gramineous crops are very low in their percentage of nitrogen, and yield but a small quantity of it per acre. Yet nitrogenous manures are very effective when applied to such crops. Leguminous crops, on the other hand, are very high in their percentage of nitrogen, and yield a large amount of it per acre. Yet nitrogenous manures are of little avail to these plants, and potass manure is especially effective. The difference in the manure requirements of plants of other natural families was also pointed out. Much more complicated, however, was the problem when experiments were made upon the mixed herbage of grass land, where they might have fifty or more species growing in association, representing perhaps twenty natural families. It was at once found that the manures which most favoured gramineous crops separately grown on arable land brought forward the gramineous plants of the mixed herbage. Those, on the other hand, which favoured the leguminosæ, grown separately, on arable land, brought forward the leguminosæ in the mixed herbage. Somewhat similar results occurred with the plants of other natural families. Hence, the twenty different plots in those experiments soon showed as many distinct floras. Tables were exhibited illustrating the variation in the number of species, their percentage by weight, and the amounts which the different natural families yielded per acre. With the great difference, not only in the flora, but also in the character of development of the plants, there was the greatest possible difference in the chemical composition. The dry matter of the mixed herbage contained in some cases 1½ time as much nitrogen as in others. The percentage of potass in the produce varied as one to two, and the amount of potass yielded per acre as one to five in the different experiments; and there were considerable differences among the other constituents. The produce of the respective natural families possessed its own normal composition within certain limits. Yet this was varied immensely according to the conditions supplied, and the character of the produce grown. Thus, the ash of the gramineous produce showed a variation in the percentage of potass of from about 24 to about 40; the ash of the leguminous produce from 12 to 33; and that of the miscellaneous produce from 17 to 37. One point of especial interest was the difference in the amount of nitrogen yielded by the plants of the different natural families. It was

assumed by some that some plants assimilated the free nitrogen of the atmosphere; but the authors considered that the balance of the direct experimental evidence on the point was decidedly against such a supposition; and so far as their existing evidence went they considered it much more probable that the different plants only took up combined nitrogen, and chiefly from the soil. They showed by reference to their experiments that in the growth of wheat or barley for many years in succession on the same land without nitrogenous manure the annual yield of nitrogen in the crop gradually diminished. With this they found a diminution in the percentage of nitrogen in the soil. In the case of the root crops, where the diminution in the annual yield of nitrogen was even greater than in the case of the cereals, the diminution in the percentage of the nitrogen in the soil was also greater. In the case of beans there was also a diminution in the yield of nitrogen in the crop, but still much more was yielded over the later period than in either wheat or barley. In this case there was not found a marked reduction of nitrogen in the surface soil. In the case of the mixed herbage experiments very much more nitrogen was yielded by the application of potass manure; and here they found a great reduction in the percentage of nitrogen in the soil. In the case of clover grown for many years in garden soil, the percentage of nitrogen in the soil was also very largely reduced. Part of this reduction might be due to other causes; but the indication was that the leguminosæ had derived their nitrogen from the soil. Admitting that the sources of the whole of the nitrogen of vegetation were not conclusively made out, they nevertheless considered that the existing evidence was against the idea of the assimilation of free nitrogen by plants, and in favour of the opinion that the nitrogen was mainly, if not entirely, derived through the medium of the soil.

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2. *The Rare Metals of the Yttrium Group.*

By T. S. Humpidge, *Ph.D.*, *B.Sc.* (*Lond.*)

This paper consisted of a few remarks on some experiments with these metals, instigated for the purpose of finding some better method of separation of the metals, and of separating the metals themselves to determine their specific heats. The main objects of the investigation produced only negative results.

The material employed for the preparation of the earth was gadolinite, and the method of extraction was the usual one. The earths themselves were separated by Bunsen's well-known method with the basic nitrates; no better means of separation could be found. Three earths were first obtained, viz., yttria, terbia, and erbia, with their usual properties. Afterwards Marignac's 'ytterbia' was looked for in the supposed pure erbia, and the existence of this new earth confirmed. The earths 'X' of Soret, 'phillipia,' and 'decipia' of Delafontaine in all probability do not exist; though at present the evidence at our disposal is too meagre for any decisive opinion to be formed.

The reduction of the fused chlorides by an electric current was attempted, but numerous experiments only yielded the metals in the shape of a powder of small metallic scales; their specific heats could not therefore be determined. As no volatile compound of these metals is known, the only other method for determining their atomic weights was by isomorphism. Rammelsberg had stated several years ago that the sulphates of cadmium, didymium, and yttrium are isomorphous, whence he drew the inference that the two latter metals (or groups of metals) are dyads, and their oxides therefore monoxides. This was proved to be incorrect by Hildebrandt's experiments with the didymium group of metals, by which he found that their specific heats were such that the atomic weights assigned to them by Rammelsberg must be increased by half as much again, so that their oxides would become sesquioxides. Kopp has lately shown, and his experiments have been confirmed by the author, that the isomorphism which Rammelsberg imagined to exist between the cadmium, didymium, and yttrium salts is forced and unnatural, and, further, that cadmium sulphate and didymium sulphate, or cadmium sulphate and yttrium sulphate do not crystallise regularly together; while, on the other hand, didymium sulphate and yttrium sulphate do so. Yttrium and the other metals of

its group are, therefore, isomorphous with didymium and not with cadmium, whence it follows that the oxides of this group of metals are sesquioxides. The numerous compounds of the yttrium metals prepared by M. Cleve are more simply formulated on this assumption than on any other.

The author exhibited a few specimens connected with this investigation.

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3. *On the Synthesis of Hydrocyanic Acid.* *By* Professor Dewar, *F.R.S.*

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4. *On the amount of Nitrous Acid produced in Electric Illumination.* *By* Professor Dewar, *F.R.S.*

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5. *On the Kinoline Bases.* *By* Professor Dewar, *F.R.S.*

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6. *An account of some Recent Experiments on Supersaturated Solutions.* *By* John M. Thomson.

In this paper the author alluded to his experiments communicated to the Chemical Society, in which he shows that perfectly isomorphous substances, that is, bodies possessing the same chemical constitution and crystalline form, are capable of exciting crystallisation in supersaturated solutions of each other. Instances were given of the different classes of salts examined, such as the sulphates of the Magnesium group possessing the general form $M''SO_4\ 7H_2O$ upon each other. Experiments were also made on other isomorphous groups, such as the group of Alums, and the phosphates and arseniates of sodium ($Na_2\ HPO_4.\ 12H_2O$ and $Na_2\ HAsO_4.\ 12\ H_2O$). The author then alluded to experiments on mixtures of isomorphous and non-isomorphous bodies with each other, pointing out that a considerable separation between non-isomorphous bodies, when mixed, may be brought about; but that this separation could not be carried out with isomorphous substances.

Mr. Thomson then described some new experiments upon the action of the different constituents upon supersaturated solutions of compound salts, such as the action of potassium sulphate on an alum solution, the action of mercury iodide or potassium iodide on the double iodide of mercury and potassium, the action of mercury chloride or ammonium chloride on the double chloride of mercury and ammonium, and finally the action of normal tartrate of potash or soda on a solution of the compound salt, viz., rochelle salt. From these experiments it seems that in the case of the double chlorides and iodides mentioned the different constituents behave as active nuclei in exciting the crystallisation of the compound salts; but that in the cases of the alum and rochelle salt solutions, the different component salts were not able to excite the crystallisation of the double salts. Mr. Thomson proposes to extend these experiments, if possible, in the direction of an examination into the condition of compound and double salts when in solution.

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7. *Notes on recent Spectral Observations.* *By* J. Norman Lockyer, *F.R.S.*

The following results have been obtained by the method recently described to the Royal Society (*Proc.* R.S., vol. xxix. p. 266):—

1. Carefully distilled sodium condensed in a capillary tube, and placed in the retort, gives 20 volumes of hydrogen.

2. Phosphorus carefully dried gives 70 volumes of gas, chiefly hydrogen, which, however, is not PH_3, although it gives some of the lines of phosphorus. It is not PH_3, because $CuSo_4$ is not touched by it.

3. Magnesium carefully prepared by Matthey is magnificent in its colourings; we get first hydrogen, then the D line [not sodium, for the green line is absent],

then the green lines of magnesium, (*b*) then blue line, then various mixtures of all of them, as the temperature is increased, D being always the brightest. 2 volumes ($\frac{1}{2}$ *cc*) of hydrogen only were collected.

4. With gallium and arsenic the pump always clicks, indicating that no gas is given off.

5. From sulphur and some of its compounds there is always So_2.

6. From indium, hydrogen comes over before heating.

7. Lithium gives 100 volumes of hydrogen.

The conditions of the experiments have always been the same, the only variable being the substance. The volumes stated are those generally obtained; almost all experiments are ended by the cracking of the tube.

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8. *Notes on Petroleum Spirit or 'Benzoline.'* *By* Alfred H. Allen.

The application of the commercial names 'benzoline' and 'benzine' to the more volatile portion of petroleum has led to great confusion between petroleum spirit and coal-tar naphtha, the most characteristic constituent of which is the hydrocarbon *benzene* or *benzol*.

Although presenting close general resemblances, the following characteristic differences exist between petroleum spirit and coal-tar naphtha. All the tests given have been carefully verified by the author on representative samples of petroleum spirit and coal-tar benzol.

Petroleum Spirit, 'Benzoline' or 'Benzine.'	*Coal-Tar Naphtha, or 'Benzol.'*
1. Consists of *heptane*, C_7H_{16}, and its homologues.	1. Consists of *benzene*, C_6H_6, and its homologues.
2. Heptane contains 84·0 per cent. of carbon.	2. Benzene contains 92·3 per cent. of carbon.
3. Commences to boil at 54° to 60° C.	3. Commences to boil at about 80° C.
4. Specific gravity at 15·5° C. about ·69 to ·72.	4. Specific gravity about ·88.
5. Smells of petroleum.	5. Smells of coal-tar.
6. Dissolves iodine, forming a solution of a raspberry-red colour.	6. Dissolves iodine, forming a purple-red liquid of the tint of an aqueous solution of potassium permanganate.
7. Does not sensibly dissolve coal-tar pitch, and is scarcely coloured by it, even on prolonged contact.	7. Readily dissolves coal-tar pitch, forming a deep-brown solution.
8. When shaken in the cold with one-third of its volume of fused crystals of absolute carbolic acid, the latter remains undissolved, and forms a separate lower stratum.	8. Miscible with absolute carbolic acid in all proportions.
9. Requires two volumes of absolute alcohol, or four or five volumes of methylated spirit of ·828 sp. gravity, for complete solution at the ordinary temperature.	9. Miscible with absolute alcohol in all proportions. Forms a homogeneous liquid with an equal measure of methylated spirit of ·828 sp. gravity.
10. Warmed with four measures of nitric acid of 1·45 sp. gravity the acid is coloured brown, but the spirit is little acted on, and forms an upper layer.	10. Completely miscible with four measures of nitric acid of 1·45 sp. gravity, with great rise of temperature and production of dark brown colour. (A certain amount of nitrobenzene may rise on cooling the liquid.)

The greater number of the above tests are valueless when applied to mixtures of petroleum and coal-tar naphthas, but No. 10 is capable of giving quantitative results if the treatment with nitric acid be conducted in a small flask and an inverted condenser attached, to prevent loss of vapours. When action has nearly ceased, if the liquid be poured into a narrow graduated tube, the measure of the upper layer indicates with approximate accuracy the amount of petroleum spirit present. If the proportion of benzene is considerable, the nitrobenzene produced may not remain completely dissolved in the nitric acid, in which case it rises and forms a layer of a dark brown colour below the stratum of petroleum spirit. Nitrobenzene and petroleum spirit are readily miscible in the absence of nitric acid, but agitation with strong nitric acid dissolves out the nitrobenzene, a portion of which may rise and form an intermediate layer as above described.

By fractional distillation, the author found that the proportion of *heptane*, C_7H_{16}, present in commercial benzoline probably equalled, or even exceeded, that of all the other constituents.

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9. *On the Illuminative Value of a Mixture of Hydrogen with some Hydrocarbons.* *By* A. Vernon Harcourt, *M.A., F.R.S., Lee's Reader in Chemistry at Christ Church, Oxford.*

The author has determined the proportions in which pentane and hydrogen must be mixed to form a gas which, burnt at the rate of 5 cubic feet an hour at a standard argand burner, gives the light of 16 candles. He has also made a comparative experiment with benzene.

The experiments were made by passing hydrogen from a gasholder into a cylindrical glass about an inch wide, containing the volatile hydrocarbon, and thence though a meter to the burner. By regulating the temperature of the liquid, and the distance between the mouth of the tube through which the hydrogen entered and the surface of the liquid, the light of the gas flame upon the disk of the photometer could be kept nearly equal to that of the candles used for comparison when the gas was passing through a meter at 5 cubic feet an hour.

Each experiment lasted one hour, at the end of which the weight of pentane which had evaporated was ascertained, and the weight of spermaceti consumed by the two candles. An observation of the illuminating power of the gas was made every minute, and the rate of evaporation adjusted so as to keep the illuminating power as nearly as possible equal to that of 16 candles.

The following results were obtained:—

	Duration of experiment	Illuminating power	Grains of spermaceti burnt	Grams of pentane burnt	
				Actual	Corrected
1	1 hour	14·6	—	36·2	39·7
2	,,	17·1	219	38·3	39·8
3	,,	16·4	217	38·7	41·9
4	,,	16·3	218	38·1	41·1
Mean .		16·1	218	37·8	40·6

The weight of pentane burnt is corrected proportionally from what it was with the actual illuminating power obtained, judged by the light actually given by the candles, to what it would have been if the gas had given the light of 16 candles each burning at the rate of 120 grains per hour.

The weight of pentane required to maintain this light for one hour is 40·6 grams. The mixture consisted of 4·55 cubic feet of hydrogen, and 0·45 cubic foot of pentane. Thirty-nine grams of pentane burnt with this proportion of hydrogen under the conditions of the experiment yield as much light as 120 grains of spermaceti burnt in a candle.

A similar experiment, was made with benzene in order to compare quantitatively the illuminative value of the two hydrocarbons:—

Duration of experiment	Illuminating power	Grains of spermaceti burnt	Grams of benzene burnt	
			Actual	Corrected
96 minutes	16·4	354	24·8	16·5

The weight of benzene required to maintain the light of 16 standard candles for one hour is 16·5 grams. The mixture consisted of 4·83 cubic feet of hydrogen and 0·17 cubic foot of benzene. Thus, while hydrogen must be mixed with $\frac{1}{10}$th its volume of pentane to yield a gas of the illuminative value of ordinary coal gas, it requires only about $\frac{1}{27}$th its volume of benzene. The illuminative value of benzene is 2·46 times greater than that of pentane, comparing the two by weight, and 2·66 times greater comparing equal gaseous volumes of the two.

If the light of a hydrocarbon flame is due to the incandescence of the carbon, or highly condensed hydrocarbons, formed at the temperature of combustion, it would seem that the products or mode of decomposition of the two hydrocarbons must differ. If the carbon of each were separated, their illuminative value would be similar. Actually carbon present as benzene vapour has 2·05 times the illuminative of carbon present as pentane.

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10. *The New Condenser.* *By* George S. Hazlehurst.

I have striven to make my condenser a contrast in every possible way to the usual method. Its principle is the exact opposite of condensing towers. Cold by rarefaction is the old idea—the gas, attenuated by the chimney draught, is drawn through long lengths of expensive glass tubing, through towers of Yorkshire flag, 5 feet square and 50 or 60 feet in height, thence to a brick tower, where it is drenched with water, thence to the chimney—sometimes not quite innocuous even then!

The new idea is cold by compression. Not new to science by any means, but new as far as muriatic acid is concerned. The difficulty has been to find a valve which would not be eaten up by even an hour's work in the hot and powerful gas —no valve would stand it—but if by any conceivable means the wear and tear and motion of the valve could be thrown solely upon the acid liquor itself, the difficulty would be overcome.

This single ray of hope soon broadened into fuller light. It was evident if a long pipe were placed, say 3 inches deep, in liquor in a closed vessel, it would be much easier to draw air down the pipe and make it bubble through the liquor than it would be to press the liquor up the tube to any considerable height; make it easier for the gas to enter than to get back; provide a readier outlet trapped in similar fashion, and you have at once a suction and a delivery.

Four large ebonite tubes, 30 inches diameter, closed at the upper end, rising and falling in liquor, alternately pull in the gas through one set of liquor traps and expel it through a second, making sufficient draught to take the gas from a pot and furnace whose farthest door is fifty yards distant. The suction valve is so arranged that when full it overflows into the delivery valve, and this again overflows into a cistern. Thus the valves are made to regulate themselves, they merely require a small supply of liquor, and apply themselves naturally to their work. In first cost, in wear and tear, and in the amount of water used, the patent offers larger advantages compared with condensing towers.

It soon became evident that the enormous amount of heat evolved from pot and furnace, and also from the gas itself by the very act of condensation, would prove a serious drawback. Fifteen-inch vertical pipes, chequered with tiles, and supplied with a stream of cool strong acid or water have hitherto sufficiently reduced the temperature to make it safe to use the ebonite tubes. The greatest

length of 15-inch pipes that I have used has been only 15 feet, and in this short length a plentiful stream of water can be changed into acid, 24° Twaddel, when the vitriol has been freshly run on the salt. Of course where the charge has boiled down this cannot be maintained with such a short length of tube, hence, up to the present, strong acid has been delivered down the tube by a pump I introduced to the trade about two years ago. Ultimately, I trust, no acid pump will be needed in connection with the condenser, but the gas cooled and the acid made from water alone.

A vertical range of 12 inch pipes filled with coke and supplied with water is provided to make away with the remains of the gas; this may be all put under pressure by narrowing the exit. There is reason to believe that a very short range will eventually be required here, even if one be needed at all.

The large powers of cooling and acid making shown by 15 feet of piping chequered with tiles, show that further development may be expected in this direction. If 15 feet can do so much, what of 30 or 50 feet? In this way I hope to dispense with acid pumping entirely.

The highest test taken at the exit pipe showed an escape of 1·2 grains per cubic foot, and the lowest test ·09 grain per cubic foot. This on a 12 inch pipe, with a speed too slow to be found in the usual fashion, would yield merely a fractional percentage on the salt used, or a figure in the third place of decimals if reckoned on a cubic foot taken from a moderate sized chimney with 6 or 8 feet of speed a second. These satisfactory results obtained at the outset are most encouraging, and lead me to hope that ultimately the very smell of the acid vapour may be quenched.

If this method prove capable of making vitriol, it will effect changes of an importance difficult to estimate.

The old plan stands aside, as it were, provides long lanes of piping in which the gas may spread its giant bulk and wander on, until weary with gradual cold, it slowly submits to the liquid form. The new plan stands directly in front of it, quenches its fire ere it has gone six yards, draws it swiftly on, and crushes it between cool surfaces of liquor until its power to harm has passed away.

WEDNESDAY, AUGUST 27, 1879.

The following Papers were read:—

1. *Notes on a Sample of Fuller's Earth, found in a Fullonica recently excavated at Pompeii.* *By* WILLIAM THOMSON, *F.R.S.E.*

In visiting the ancient city of Pompeii in April last, I observed in one of the Fullonica establishments a large square tank set in the ground, filled with a white, soft substance, which was soapy to the touch, and which was pointed out to us as the soap of the ancient inhabitants. I took a sample of the substance with a view of making a chemical examination of it.

This substance is named by the Italians 'Terra Fullonica,' and besides being found in the dyers' and washers' quarter of the city, it has been discovered frequently in the ordinary houses which have been excavated.

Among the literature of chemistry I searched for but failed to find any mention of this Fuller's earth or its composition, but through the kindness of Signor Felice Niccoline, Director of the National Museum of Naples, I obtained a pamphlet written by Professor de Luca, entitled, 'Chemical Researches on "Terra Fullonica," found in Pompeii, April 13, 1878.'

In this he gives the general chemical peculiarities of the clay, such as its being

faintly alkaline and containing silica, lime, magnesia, chlorides, and traces of sulphates—potassium and sodium. He gives its composition, according to a mechanical analysis, as follows:—

50 grams	of the clay stirred in water gave different residues, which were separated according to their tendency to settle to the bottom.	
10·282	„	settled first, and was composed of sand and carbonate of lime.
17·710	„	was composed of a little sand and carbonate of lime and much clay.
10·050	„	is formed of traces of carbonate of lime and much clay, and the fourth residue.
8·230	„	was greasy to the feel and plastic, and fused before the blowpipe into a vitreous bead of a yellowish-white colour.

Professor de Luca also states that it contains 17 per cent. of water, 24 per cent. of matter soluble in hydrochloric acid, and 2·7 per cent. of carbonic acid; the remainder being insoluble in hydrochloric acid.

On drying the substance thoroughly at 100° C., and then subjecting it to analysis, I found it to be composed of—

	Per cent.
Silica	67·145
Alumina	12·857
Oxide of iron	2·107
Lime	6·412
Magnesia	1·822
Carbonic acid	3·451
Manganese	Trace
Combined water	3·953
Alkaline salts (loss)	2·253
	100·000

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2. *On the Detection of Milk Adulteration.* *By* William H. Watson, *F.C.S.*

From analyses of milk from various dairies, and by a comparison of the results obtained with circumstances existing as to the character and quantity of the food; nature of different cows; conditions and health of them at particular periods; and changes of the seasons of the year, the author concludes that cows' milk is subject to considerable variations in composition. He has found in many instances milk from well-fed healthy cows to contain as little as 10·5 per cent. of total solids, and from 8·5 to 9 per cent. of solids not fat. The results of other experimenters are compared, and it is then suggested that the present limits adopted by public analysts for genuine milk should be reconsidered.

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3. *Chemical Researches on Palmella Cruenta.* *By* Dr. T. L. Phipson, *F.C.S., London, formerly of the University of Brussels, Cor. Memb. of the Chemical Society of Paris, and of the Royal Society of Med. and Nat. Sciences of Brussels.*

I.

Palmella cruenta is a minute alga, of a blood-red colour, which is found at the foot of damp walls, especially where there is much mortar or lime-wash, and always near to the ground. The older botanists called it *Chaos sanguinea, Tremella sanguinea,* &c., and during wet weather, in summer, this minute plant is not unlike clotted blood.

But when giving to it the names just mentioned, botanists could not have foreseen how far this analogy extends, and how many curious points of resemblance this

vegetable production possesses with the blood of animals. In the first place, when observed under the microscope, it is found to consist of minute spherical cells, about 0·004 of a millimetre in diameter, according to my own determinations, and these may be easily likened to human blood corpuscles, which I find measure 0·005 to 0·006 of a millimetre, with the same instrument. These little cells, each distinct and independent, swarm in a kind of mucous substance which may, for analogy's sake, be compared to the serum of the blood. But I have found that they contain a colouring matter of a very remarkable character, that will be here spoken of as *Palmelline*. Up to the present time there is no substance known to chemists which at all resembles it, except the colouring matter of blood, or *hemoglobine*. Like the latter, it is insoluble in alcohol, ether, benzol, and sulphide of carbon, but dissolves in water. Like the colouring matter of blood, palmelline is dichroïc; like it, also, its aqueous solution is coagulated by acetic acid, alcohol, and ammonia, and it is a colouring matter of an *albuminous* nature. Like hemoglobine, the new substance, palmelline, also produces wide bands of absorption in the yellow of the spectrum, though not exactly in the same position. The solution of palmelline in water easily undergoes putrefaction with development of ammonia, precisely as does the colouring matter of blood. Finally, like hemoglobine, palmelline contains a little iron.

These and other strong analogies are certainly extremely curious, since the two substances are really distinct; in other terms, the analogy does not amount to identity. But it is the first time that any substance at all similar to the colouring matter of blood has been discovered in the vegetable kingdom.

Palmelline cannot be extracted from the little plant whilst the latter is in a moist state, for, then, its vitality is such that it does not allow water to extract the colour. The plant must be dried by exposure to the air for some twenty-four to forty-eight hours, *without the application of any artificial heat.* It must then be placed at the bottom of a porcelain dish containing a little cold water, the dish being covered with a sheet of glass, and allowed to remain for another period of twenty-four to thirty-six hours. By that time the colouring matter is almost all exhausted, and forms a beautiful *rose pink* solution, if seen by *transmission*, and *orange yellow* by *reflection*. No other colouring matter is extracted from the plant in this manner. The dry plant may also be treated first with sulphide of carbon, and then by strong alcohol; being afterwards thoroughly dried, water will then extract the palmelline as before.

Evaporated to dryness at about 40° C., the solution yields the substance in question, as more or less crystalline crusts, without any definite form.

The solution is coagulated by alcohol, ammonia, and acetic acid, producing in each case flocks similar to the fibrine of blood. It is also coagulated by heat, like albumine. It yields several wide bands of absorption in the spectroscope: these are situated below D in the yellow, and extend into the green of the spectrum.

Palmelline is insoluble in ether, alcohol, or sulphide of carbon and benzol. Its solution in water enters easily into putrefaction at 25° to 30° C., with a very strong ammoniacal odour of putrid cheese, and development of swarms of active *vibrios* and *bacteria*. This decomposition can only be prevented, so as to preserve the colour, by saturating the recent aqueous solution with ether. As long as the odour of ether is perceptible in the flask, no decomposition sets in. A little salicylic acid also preserves the solution for a week or so; but it modifies the colour, turns it more or less violet, and takes away the curious yellow fluorescence, which is so characteristic of palmelline.

When the aqueous solution is coagulated by alcohol, the palmelline is precipitated as red filaments like fibrine, which soon become colourless. Ammonia and potash act in the same manner, first turning the pink to a greenish-blue shade, and afterwards destroying the colour. Sulphide of ammonium turns the solution yellow without coagulating it. Hydrochloric acid and nitric acid change the tint of the solution to brick red, which is no longer dichroïc, and then destroy it, without coagulation.

When a few drops of palmelline solution were treated so as to obtain what are called microscopic 'blood-crystals,' like the crystals produced by *hematine* with

acetic acid, I obtained a great quantity of rhombic (nearly cubic) plates, colourless, or only slightly coloured. A second experiment gave the same result.

When palmelline obtained by the evaporation of its aqueous solution at 40° C is calcined, it leaves a small quantity of ash, in which lime chlorine and iron were detected.

II.

If, instead of drying the little plant by exposure to the air, in order to extract the palmelline, as described above, it is allowed to steep for some hours in a large excess of sulphide of carbon, this liquid soon becomes a dark golden-yellow colour, and on evaporation leaves, together with a little fatty matter, a large quantity of *xanthophyll*—the yellow colouring matter of leaves in autumn—which is characterised, as I showed in 1858,[1] by dissolving in concentrated sulphuric acid, with a magnificent emerald green colour. After the complete separation of the sulphide of carbon, strong alcohol extracts *chlorophyll* in a very pure state, forming a beautiful bluish-green solution, which, on evaporation, yields nothing but chlorophyll; and this is, perhaps, the easiest mode of obtaining the substance in a state of purity. When, after these two operations, the alcohol is completely separated, pure cold water extracts the *palmelline* in the course of about twenty-four hours.

By these successive treatments, xanthophyll, chlorophyll, and palmelline are entirely separated, and the *Palmella cruenta* contains no more colouring matter.

III.

But both the treatment by water and that by alcohol, as above made known, separate, at the same time as the substances already named, small quantities of another very interesting compound, which I have isolated and have termed *Characine*. It is the odoriferous substance which is characteristic of fresh water *algæ*, *desmids*, *diatoms*, *oscillariæ*, &c., in general, and is highly developed in plants of the genus *Chara*, giving to all these that peculiar *marshy odour* so well known to botanists. This odour is due to a substance produced by the plants (a kind of camphor), and not, as is generally supposed, to some products of their putrefactive decomposition.

Characine can be extracted from the alcoholic solution, or from the water which has lain over the dry *Palmella cruenta* for thirty or forty hours. The alcoholic solution is first mixed with about fifteen times its volume of water, and allowed to deposit in a closed tube; the contents of the tube are decanted from the deposit, and shaken up with a certain quantity of ether. The latter is then separated and evaporated. It leaves the characine in the form of a colourless greasy substance, having a *strong characteristic marshy odour*. It is soluble in alcohol and ether, almost insoluble in water, to which it communicates its odour; its specific gravity is less than that of water, on which it floats, producing those thin films which are seen occasionally on stagnant water abounding in algæ, and on the water of tanks where algæ are cultivated. Potash does not saponify it. Abandoned to itself it either volatilises or disappears by oxidation from the surface of cold water, which thus loses all marshy odour. But when heated in contact with water, in a closed tube, it yields a substance melting at 83° C, very similar to 'vegetable wax,' and having the odour of that substance.

It can also be obtained from water which has stood for two days on the air-dried *Palmella*. On the surface of the liquid, which is of a beautiful rose pink from the palmelline it has dissolved, are seen numerous thin films of characine. The liquid can easily be decanted off into a long narrow tube, and shaken up with ether, which extracts the characine and respects the colouring matter.

Characine is the substance to which all the fresh-water algæ, oscillariæ, &c., owe their peculiar odour whilst in life and health. The *Chara fœtida* is, perhaps, the plant in which it is most developed. I hope to make a more complete study of it at the first opportunity.

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[1] Phipson, *Comptes Rendus*, Paris, 1858; and Würtz, *Dict. de Chim.* art. 'Couleur des Feuilles.'

4. *Description of a Glass Burette for Collecting, Measuring, and Discharging Gas over Mercury.* *By* PHILIP BRAHAM, *F.C.S.*

THE burette consists of a divided glass tube open at both ends, the lower end, A, having a lip and the upper end being covered with a loosely-fitting boxwood cap.

A piston, B, formed of a disc of india-rubber between two plates of steel, connected to a steel rod, C, is fitted into the tube.

To fill the burette, the piston is depressed below the lower end until some of the mercury escapes above it, and on drawing it up any portion of the tube can be filled.

When the gas has been delivered its measurements may easily be made by lowering the piston till the mercury inside is level with that out, and the content read off. By placing the lip under a eaudiometer, on further depression of the piston any required amounts of gas may be delivered for analysis, the clamp E being fixed to stop the piston when the required amount is discharged. The clamp D is used to prevent the piston descending when the instrument is full of mercury.

Section C.—GEOLOGY.

President of the Section—Professor P. Martin Duncan, F.R.S., Vice-President of the Geological Society.

THURSDAY, AUGUST 21, 1879.

The President delivered the following Address:—

Everyone who is interested in the science which is especially considered in this section of the British Association for the Advancement of Science must be impressed with the importance of the geological construction of this district in determining its physical geography, in producing the features of its landscapes, and in originating and developing many of the industries of the busy town of Sheffield.

It was inevitable that you should be addressed, at the commencement of your labours, upon the subject of the Carboniferous formation, especially as the intention of this peripatetic congress is to advance science amongst those who require it. It will therefore be my privilege to bring before you some of the more important generalisations of the day, and some other considerations, regarding the great formation which is so fully developed in this part of England; trusting that whilst many of you will submit to be reminded of the results of the labours of the men who have established our science and of those of yourselves, some who desire further information than they have hitherto obtained may be advanced in knowledge.

Of all geological formations, the Carboniferous is the most important to mankind at the present time, and the most interesting to the student. It gives the earliest clear and definite idea of a land surface on the earth, or rather of the existence of many lands; for they are to be traced here and there from high up in Arctic latitudes to Australia, and from the West of America to Eastern Asia. It offers evidence of the existence, even in those remote days as in the much later Miocene age, of astronomical conditions which do not now prevail. It yields proofs of the persistence of a vast lowland flora during extraordinary vicissitudes of the relative level of land and sea, and of the existence of a fauna remarkable for its great fish and amphibia, and whose air-breathing mollusca and insecta are of surpassing interest, foreshadowing as they do many recent forms. And its study indicates that the movements of the crusts of the earth, which occurred during and terminated the age, were of the grandest kind, and have been of the greatest importance to mankind, destroying, it is true, all the vestiges of a large part of a volume of the earth's history, but bringing coal within the reach of the explorer and miner.

This world-wide formation, usually very thick everywhere, has all the evidences of having lasted during a vast age, and there are present in it the relics of sea flows, of shallow seas and estuaries, of land surfaces, rivers and marshes. The volcanic activity of the age was great, and is capable of demonstration.

So deep are some of the sediments composing the Carboniferous formation in different parts of the world that the idea of exact contemporaneity is not necessarily much modified. It was in all probability coal time universally, and for a long duration. But the beginning of the period was not synchronous in different parts of the earth, neither was the ending. The Devonian age lasted longer in

some parts of the earth than in others, and the crust movements which so altered the physical geography of the Carboniferous hills, dales, and swamps as to develop a new aspect of nature, terminated the period sooner in some quarters of the globe than in others. In such a locality, however, as Eastern Hindostan, the duration of a Carboniferous type into the secondary ages is apparent. Hence, in spite of a recognised general contemporaneity, it must be credited that Carboniferous, Devonian, Permian, and later deposits were accumulating early and late during the lapse of one great age in distant parts of the globe.

The duration of the Carboniferous age in the broadest sense may be attempted, but with no great success, to be estimated by the time which must have elapsed during the world-wide dispersion of identical species; and its biological relation to the preceding and subsequent formations may be appreciated from the fact that the Carboniferous flora, lasting as it did from the bottom to the top of the formation, was foreshadowed in the Devonian, and that it founded the Mesozoic. Thus the Australian, Himalayan, British and North and South American marine strata of the Carboniferous age contain many identical species of Brachiopoda—the variation from the English types, which were the first described, being very slight. Amongst the corals some forms are equally widely diffused. Now, according to what occurs in nature at the present time, the movement of species from one locality to another by ova, or by wafting of the young—the only method of the lateral or horizontal progress of the Brachiopoda—for instance, is impeded by many physical conditions, and is constantly rendered abortive by predaceous and obstructive living forms, and by what is called the struggle for existence. Migration, or rather the extension of the locality of the species, for the first term implies much more than was or is ever done, is so rarely possible to any great extent under the present complicated natural history and physical condition of the earth, that the mind fails to grasp the time which would lapse between the commencement of the dispersive process and the establishment of identical species, even a few thousands of miles off. To bring the subject a little nearer, however, it is necessary to consider that the Arctic and Antarctic cold areas and the frigid bathymetrical ocean zones did not then exist, and that the movements of the crust, producing extension of coast lines, were exceedingly frequent during the age, and must have facilitated the dispersion of littoral and moderately deep sea species.

The dispersion of the species of the numerous cryptogamous plants was doubtless rapid in relation to that of the animals, for their spores could be wafted to a great distance by wind, and they do not appear to have had much to struggle against. With the Coniferæ it was different, and the examination of the methods in which fir trees spread in favourable localities at the present time is very suggestive of exceeding slowness of dispersion. Nevertheless, the cones of the Coniferæ were carried here and there by water during the Carboniferous age.

To add to the notion of the long duration of the age it must be remembered that a succession of identical floras occurred nearly on the same areas, involving repetitions of growth and of migration.

The growing of the vegetation of each swamp and lowland tract, its accumulation and covering up with sand, shales, and gravel, occupied much time, and the last process involved the destruction of considerable breadths of plant life. The formation of under-clay or warp, if the similar occurrences of the present day be taken as examples, occupied much time, and then a lapse occurred, whilst the nearest flora supplied a new vegetation to the virgin soil.

In some instances the recurrence of vegetation was evidently the result of spreading from no great distance; but in others so great a depth of sediment separates the consecutive deposits of coal, and the great subsidence which took place is so evident, that the migration must have been from a considerable distance, and must have occupied commensurate time. In endeavouring to appreciate this lapse of time, it must be remembered that, even on the small surface of the United Kingdom, there was land on some parts during the whole of the Carboniferous Age, notwithstanding the diversity of the deposits and the frequent occurrence of marine conditions.

It would appear that prior to those movements of the earth's crust which ter-

minated the physical geography of the Devonian Age, three elevated tracts of land crossed the kingdom from west to east, and that there were mountainous regions running northwards and north-westwards, including North Wales, Western Ireland, and much of the North Atlantic.

The southern high land barrier passed somewhere in the direction of the Bristol Channel, and then to the east and slightly to the south, having a somewhat definite continuation with the Ardennes. The central barrier, or high land, passed from Shropshire eastwards by Leicester, and then to the coast; and the northern was formed by hills in the present Lake district, extending eastwards. On the south of the southern high land, the marine Devonian accumulated in a coral sea, and to the north of it and between it and the central barrier the Old Red lakes obtained their water supply and sediment from the Welsh hills of the period. North of the central barrier interrupted lakes and land occurred and also to the north of the northern barrier. The dry land and the barriers and hills were formed by sub-rocks of Silurian and Cambrian age.

There is no evidence to indicate that the southern barrier was of great height at the end of the Devonian period, but there is some which points out that the first physical change which initiated a new aspect of nature—the Carboniferous—was a general subsidence of the region. The coral reefs sank below the bathymetrical zone of the composite forms, and the sea breached the barrier. The southern Old Red lake began to have its waters impregnated with salt, and its great ganoid fish were replaced by the cestraciont sharks of the age. These left their remains in the bone bed at the base of the lower limestone shales, which are the earliest of the Carboniferous series there. The irruption of the sea appears to have taken place to the north of the central barrier also, and the subsidence was great there, a limestone with some sandy strata forming gradually. In the north and north-east, in the present district of the Tweed, deposits collected in shallow water, and vegetation grew which formed the coals at the base of the great Scour limestone.

On the same and on slightly higher horizons are the coals of Fallow Field, Tindall Fell, and Heskett. These are the earliest evidences of the Carboniferous vegetation, and it was doubtless in full vigour whilst marine conditions existed to the south.

Probably the high lands constituting the barriers were not covered during the subsidence, which permitted the accumulation of the marine deposits of the Carboniferous limestone age. For close to the coal-fields near the central barrier, and which rest on upper Silurian rock, borings here found the remains of Carboniferous plants on the palæozoic rock without the intervention of any sediments.

Now the depth of the deposit of limestone about this central barrier is great, and the question arises how was it produced in the immediate proximity of land which was not covered by sea, and which does not appear to have sunken contemporaneously with the sea floor close by? Sinking along definite lines bounded by faults, is the only means by which this can be explained; and this suggestion, which was a favourite topic with Phillips, is all the more probable, when it is remembered that the area of accumulation to the north of the barrier was one of vast subsidence during the consecutive ages of the grits and coal measures, whilst there was land still further north. If the stability of one and the instability of the other are not conceded, the original height of the barriers must have been stupendous and beyond example, so far as the size of their bases is concerned.

There are many examples of what I resolved to call in a presidential address before the Geological Society areas of comparative instability and which relate apparently to radial upheaval subsidence along long lines of country where movement has been rare. An instance on the grandest scale is seen in the history of the Himalayas in relation to the peninsula to their south and south-west. For whilst this last area was land during a vast age, that of the Himalayas was repeatedly a marine tract, and suffered subsidences and elevations.

Still further north and beyond the northern barrier, in the Scottish area, Carboniferous plants lived a little later, and after a subsidence which permitted the lower Calciferous series to accumulate. The lowest coals of the basin of the Clyde are of this age, and the accompanying clay, ironstone, and the fresh water limestones

and gigantic fish of Burdie House are all indications of terrestrial conditions. All these evidences of Carboniferous vegetation occur in the geological horizon of the Carboniferous limestone and Yoredale series.

Never entirely free from sandy impurities the Carboniferous Limestones north of the central barrier gradually became covered with a thick arenaceous series containing here and there marine fossils and traces of coal plants. Those on the Yoredale strata consist mainly of the sediments of a somewhat distant north-westerly land, the plants of which were carried to sea by rivers and deposited here and there on the sea floor. It would appear from the evidence collected by the Geological Survey that, after a very considerable thickness of these rocks had collected, either a filling up of the shallow sea or a slight upheaval of the floor occurred, for denudation of their surface happened, considerable depressions and ridges being produced on it. On those spaces and ridges, and indeed on the whole surface of the Yoredale rocks, collected strata which are popularly called the millstone grits, so well seen west of Sheffield. All the depths of this great land wreckage, consisting of silicious and felspathic sandstones and shales, accumulated on a sinking area, some near land and the rest in deeper places. And here and there coal seams are found intercalated, being evidences of the existence of contemporaneous vegetation. Some of them are workable, and others are only valuable as evidences of the existence of the vegetation of the age; many are placed on a hard silicious or ganister bed, but some have an underlying fire-clay. They are very usually covered with deposits containing goniatites and aviculopecten, which doubtless are the remains of marine organisms.

Admitting, therefore, that some of this millstone grit coal may be the result of the drifting and sinking of the vegetation from off lands rather remotely situated, it is still evident, from the existence of the under-clays elsewhere, that some of the grits, by silting up, or by slight upheaval, above sea level, formed the subsoil of swampy ground on which vegetation grew. This approach of the millstone grit sea floor to above sea level was decided enough in the region of the great coal-field around us, for a conglomeratic rock—the rough rock—occupies a somewhat definite horizon on the top of the series.

This rough rock collected in shallow water, and it is important to the geological surveyor, for it formed the base on which the coal measures proper rest; and it is suggestive to the physical geologist that a general and wide, but not great, upheaval took place which removed the ocean of the day further off, and which determined a total change in the direction of sediment-depositing currents.

Hitherto the greatest thickness of the sediments of the millstone grit age had been towards the north-west, and the direction of the currents had been from north-west to south-east, but subsequently, as has been suggested from very strong evidence by Sorby, the depositing currents of the next age had no very definite direction. But the Carboniferous land of this part of Europe was not yet remote from the sea. Much of it was on the borders of estuaries, and the aspect of nature was probably that of wide flats of grit covered usually by terrestrial vegetation and occasionally overwhelmed by sea. In fact, both practically and theoretically there is much difficulty in separating the millstone grits from the lower coal measures. The lower measures contain some thick and widely-spread sandstones, and the important coal seams, in some instances rest on a hard ganister bed, and in others on a fire-clay. And to add to the similarity of the deposits of the upper grits and lower coal measures, marine fossils, such as species of goniatites, aviculopecten, and posidonomya, are intercalated above the coals. But the evidences of marine invasion ceased as the deposits accumulated, and more perfect terrestrial conditions arose. The Elland flag-stones, for instance, such prominent features to the west of this town and in the neighbourhood of Halifax, are fresh-water deposits, and are undoubtedly accumulated in an under-clay indicative of terrestrial conditions.

In the region north of the northern barrier successive coal seams and impure limestones and fire-clays occurred during the age of the depositions of the English grits, and then a thick fossiliferous sandstone was followed by the upper coals of Mid-Lothian.

All the minor upheavals and upsiltings of this long age were subordinate to a

progressive general subsidence, in which the central and northern barriers were slightly implicated, and this extraordinary crust movement was to continue during the accumulation of over 3,000 feet of coal measures and other deposits, all subaerial in their method of formation, or having collected in shallow water or swampy ground. These products of denudation and of organism succeeded each other time after time; great gravels, shales, and sands were intercalated, and even traces of some of the rivers of the age are to be found breaching the seams. The more the subject, commonplace as it may be thought, is considered, the more astonishing does it become, for the regularity of the subsidence and its amount must have kept pace with the thickness of the accumulating deposits. That there were many long intervals of quietude in the earth's crust may be gleaned, not only from the thickness of many coal seams, but also from the subaerial denudation which occurred. For instance, high up in the eries in this district, is a mass of red sandstone which covers the denuded middle measures beneath; and this red rock of Rotherham, the result of coal measure denudation and removal, accumulated during the early days of the upper coal measures, for it is lower in the geological series than some members of the uppermost coal measures.

Before the close of the age, marine conditions occurred in the rock, and a limestone with goniatites was formed; but still coal seam formation proceeded until a totally different series of crust movements commenced in this country.

The flexures which were produced at the close of the Carboniferous age had their long axes east and west; they suffered denudation and on the worn edges of their strata rest the 'used-up Carboniferous'—the lower Permian. Elsewhere, resting apparently and often really conformably on the Carboniferous strata, the Permians accumulated until great north and south curvatures occurred and produced the Pennine chain.

The denudation of the anticlinal or upward curves of the north and south flexures progressed, and the coal measures, once continuous across England, were worn off along the back-bone of the country and from off the east and west ridges also. Vast as was the destruction and removal, there was still more compensation in nature, for faulting occurred on a large scale, and the measures were in many places sunken down below the level of possible subaerial denudation. It is to the pre and post Permian crust movements in producing basins and in uptilting the formerly horizontal seams, and to the subsequent faulting, that we owe the preservation and the possibility of reaching and working much of the coal of this country.

It appears that the position of this town refers quite as much to some remarkable faults, and the results of the past Permian uptilting, as to the presence of the river Don. Two important lines of fault run almost parallel, the one traversing the centre of Sheffield, and the other being to the north of the outcrop of the Silkstone coal. They pass, nevertheless, in a north-easterly direction, and the country between them is much broken. Moreover, by a combination of the results of uptilt and faulting, the strike of important coal seams has been so altered that they encircle the town on the south, west, and north. The mineral products have thus been brought within the reach of those by whose industry this town has increased in size and population.

With regard to the lithology of some of the great series just mentioned, it may be suggested that the condition under which the beautiful limestones of the Avon, and the dark, shaly, muddy, calcareous deposits of the corresponding age accumulated in Scotland, were very different. The stone in the southern example is many-coloured, and is nearly an organic deposit, whilst the shaly strata of the northern series have crowds of calcareous fossils in them. Remove the shaly substance, however, and consider and compare the fossils of both localities, and no satisfactory distinction can be drawn between the depths at which they may have accumulated.

Both deposits contain crinoids, polyzoa, brachiopoda, and simple and compound hydro-corals. The same occur in the limestones to the north of the central barrier, which are intermediate in the arenaceous condition between those just mentioned. It is admitted that the mineral condition of the original deposits has altered, and

it is possible that much impurity may have been removed by percolating carbonated waters from the purest of the limestones. And, indeed, unless this is credited, it is impossible to compare some of these old marine sediments with any now forming on the floor of the sea. All the known calcareous sea floor deposits contain a very considerable percentage of silica and other matters, and if the Carboniferous limestones were ever in the condition of modern deep-sea ooze, in order that they should have looked like the chalk they must have lost, in some manner or other, more than 35 per cent. of impurities. So far as I can understand, much of the Carboniferous limestone may have accumulated at no very great depth and on banks within the scour of currents, and their prevalence would account for the comparative absence of sandy sediments in some situations. No traces of Atoll formation exist.

With regard to one or two late discoveries relating to the organic remains of the Carboniferous limestones, it is necessary to refer you to Moseley's important work amongst the Tabulata. These must now be removed from the true stony corals, and some will be relegated to the Hydrozoa, and others to the Aleyonaria. It is a fact of great interest that Sorby should have noticed that whilst the modern true corals are built up of carbonate of lime in the form of arragonite, the great tabulated forms of old are composed of calcite.

Quite lately Mr. Busk has been investigating the large polyzoa of the genus Heteropora, and I saw, under his manipulation, that this recent and Crag group, with strong palæozoic affinities, is so constructed that the branching tubular organisms of the oldest rocks with perforations in their walls and tabulæ must be included amongst species of genera closely allied to it.

A host of ill-defined tubular forms, such as the Stenoporæ, will thus find a final zoological resting-place.

The arenaceous series of the Carboniferous formation in England are not less wonderful than the Calcareous. They thin out very rapidly from 10,000 feet in the Burnley district to 100 close to the central barrier in Leicestershire, and it would appear that the sea drift was from the present region of the North Atlantic, along the shores of the swampy coal-plant growing land.

The arenaceous deposits to the south of the central barrier have the same general relation as those to the north, and the grits of the Welsh and Bristol coal-fields are silicious, and were in all probability derived from the Silurian and Old Red rocks to their north-west. The culm measures of Somersetshire and Devonshire—those thick deposits with impure thin coals with limestones towards the bases—are of the age of the upper parts of the Carboniferous limestones and of the grits of the central area. The evidences in this age of the denudation of granite and other silicious lands, and of more or less distant diffusion of the sediment, extend far and wide from the United Kingdom, a belt of similar rocks being found in south-western and central Europe. It is, moreover, very probable that the upper Vindhyan rocks of Hindostan, those fine sandstones and grits which have yielded the building-stones to the great Gangetic cities, are of the same relative age (or slightly older) as the strata of which so many Yorkshire towns are mainly built.

Whence came the thousands of feet of the sands and shales of the coal measures? is as yet a question which cannot be answered. It appears that very widely distributed deposits of the same kind are comparatively rare amongst them, and that most of the organic deposits, as well as the inorganic sedimentary, do not extend over great breadths, but are more or less lenticular in shape, or thin out or become changed in their lithology. This fact and Sorby's suggestion that the currents which deposited the strata had not any definite course rather tend to the belief in the former presence of a vast delta during that ancient aspect of nature. It is certain that some of the vegetation which subsequently became coal, and many feet of the roof above, were not always formed with great slowness, for stumps and trunks of trees have been found standing where they grew, with their roots in their under-clay and their stems wrapped round with coal, and the shale and gravel above. Moreover, in some places, a series of these interesting relics exists, one set being placed above the others.

With regard to the coal itself, varying as it does in its physical peculiarities,

all that has an under-clay grew as vegetation on land. It is at present rather difficult to believe that where a coal seam is found upon a hard silicious bed without a vestige of clay or of old soil, its plants were rooted there. But the stigmarian roots are not unfrequent in the ganister, and at the present time a peculiar vegetation is growing on the grits to the west of this town with a very small amount of humus intervening. Some coal seams, especially the cannels, would appear, however, not to have been produced by plants which grew on the rocks beneath, and they are the result of vegetation drifting and becoming water-logged.

In reflecting upon the history of those Carboniferous deposits in relation to the subsequent great changes in the physical geography of the earth, the idea that geological histories repeat themselves does not obtain that importance with which it is credited in relation to human events. It is true that there were important Triassic, Oolitic, Wealden, Neocomian, and Tertiary lands whose vegetation has been metamorphosed into a kind of coal. But the wonderful depth and the extraordinary vertical repetition of organic and inorganic deposits, of the Carboniferous formation, and the remarkable crust movements which enabled them to accumulate, are without subsequent examples.

In conclusion, I must remind you that the volumes of the 'Geological Record' give the literature of the Carboniferous formation year by year, and that lately a magnificent contribution to the subject has appeared in the memoirs of the Geological Survey of England and Wales in the form of a great volume on the geology of the Yorkshire coal fields, by Professor Green, one of our Vice-Presidents, and Mr. Russell. A very concise and excellent geology of the West Riding has also recently been published by Mr. Davis, who is amongst us to-day, and Mr. Bauermann has contributed a capital article on coal to the 'Encyclopædia Britannica.'

The following Report and Papers were read:—

1. *Seventh Report of the Committee appointed for the purpose of recording the position, height above the sea, lithological characters, size, and origin of the Erratic Blocks of England, Wales, and Ireland; reporting other matters of interest connected with the same, and taking measures for their preservation.*—See Reports, p. 135.

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2. *Notice of the occurrence of a Fish allied to the Coccosteus in a bed of Devonian Limestone near Chudleigh.* By JOHN EDWARD LEE, *F.G.S., F.S.A.*

In this paper the author mentions the discovery of a fish, allied to coccosteus, in the Devonian Limestone of Lower Dunscombe, near Chudleigh, and endeavours to show that this fish occurs in the middle or upper part of the Devonian Limestone, just as it is found chiefly in the upper beds of the Old Red Sandstone. He also points out that, from being associated with goniatites, clymenia, and crinoidal remains, it cannot have been a fresh-water fish.

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3. *Notice of Fossils found in a bed of Devonian Rocks at Saltern Cove, in Torbay, and in a quarry of the Old Red Sandstone, near Caerleon, in Monmouthshire.* By JOHN EDWARD LEE, *F.G.S., F.S.A.*

In this notice the author states that the fossils found at Saltern are precisely similar to those found at Büdesheim, in the Eifel, which are commonly considered as Upper Devonian, and he therefore believes that, as the fossils are identical, this small exposure at Saltern may be considered as Upper Devonian. He exhibits a small series of fossils from both places, to show their identity.

The latter part of the paper describes a quarry of the Old Red Sandstone in Monmouthshire, containing apparently an abundance of comminuted vegetable remains, and also several specimens of pteraspis, one of which he believes to be new.

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4. *On the Nomenclature of the Plates of the Crinoidal Calyx.*

By P. Herbert Carpenter, *M.A.*

According to the present system of nomenclature there are two distinct sets of plates in the calyx of the Crinoids, to which the name *basals* is given. In *Platycrinus*, and in all those forms in which there are only two sets of plates in the calyx, the upper set were called *radials* by Müller, while he termed the lower set, resting on the upper stem segment, the *basals*. This was perfectly correct, for their position is interradial, and they correspond in every respect to the basals of *Pentacrinus*, the calyx of which genus was taken by Müller as a type on which he based his analyses of the calyx in all the other Crinoids.

In *Cyathocrinus*, however, there are two rows of plates below the radials, and the plates in the lowest of these were called basals by Müller because they rest on the upper stem-joint. Nevertheless, they are not homologous with the basals of *Pentacrinus* and *Platycrinus*, because they are radial in position. But intervening between them and the radials is a second set of plates (the so called parabasals or subradials), which alternate with both series, and are therefore interradial. I regard these plates as the true basals, while the lower (radial) set are homologous with the under basals of *Encrinus*, which were discovered by Beyrich. They are absent in the *Apiocrinidae*, except perhaps in *A. Murchisonianus*, in all the recent species of *Pentacrinus* and in most of the fossil species, but they occur in *P. briareus* and in *P. subangularis*, where they have been wrongly described as the basals. This name, however, really belongs to the next series of plates, the so called parabasals, or subradials, which are inter-radial like the basals of *P. caputmedusae*, and pierced like them by bifurcating canals, so that there is no doubt as to the homology of the two series.

The American palæontologists have sometimes followed Beyrich and sometimes followed Müller in their system of nomenclature. For example, *Heterocrinus* has two rows of plates below the radials which are variously called (1) subradials and (2) basals, or (1) basals and (2) sub-basals. The relative positions of these two rows are always the same, the upper (subradials or basals) being interradial, and the lower (basals, or sub-basals), being radial. As the former (interradial) series represents an important element in Echinoderm morphology, being homologous with the (likewise interradial) genital plates of the urchins and star-fishes, and is also of great morphological importance in the Crinoids themselves, it is very desirable that it should always bear the same name; and also that this name, *basals*, should not be used for plates which are neither interradial in their position nor constant in their occurrence. Similarly-named parts are usually supposed to be homologous; but if we give the same name to plates which are radial in one species and interradial in another, we disregard the principles of homology altogether, and introduce unnecessary confusion into the study of echinoderm morphology.

Beyrich has already remarked on this and has led the way towards a more rational and scientific nomenclature, by introducing the name '*under-basals*' for the radially situated plates which occur beneath the true basals of *Encrinus*.

If it be objected that these under basals, resting as they do upon the upper stem-joint, form the true base of the calyx, let us retain the name basals for this radial series, and call the upper (interradial) series the sub-radials, as is generally done at present. This, however, would necessitate our discarding the name basals altogether for such forms as *Pentacrinus caputmedusae*, &c., and, as it was first used for the lower row of plates in the calyx of this species, such a step would be inconvenient. The fact remains that the lowest part or base of the calyx is formed in some Crinoids by interradial, and in others (the minority) by radial

plates; and the precise nomenclature we employ is not of much consequence. The important point is that homologous parts should be similarly named, and that parts which are not homologous should not receive the same name as if they were so. In the latter case, Echinoderm morphology, and especially that of the Crinoids, becomes greatly confused. We cannot then say that the basals of the Crinoids are homologous with the genital plates of the urchins and starfishes. One set of plates so-named does answer to this description, but the other set does not, for it is altogether unrepresented in the other Echinoderms.

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5. *On the Coal Fields and Coal Production of India.* *By* V. Ball, *M.A., F.G.S., of the Geological Survey of India.*

When exhibiting the new geological map of India to this Section at the last meeting of the Association in Dublin, the author gave a brief sketch of the geology of India. On the present occasion he deals with the economic resources of one of the principal formations.

The coal-bearing rocks of Peninsular India are all included within the limits of the great series of plant-bearing rocks to which the term Gondwana has been applied, and they are further limited to two groups of rocks which occur in the lower portion of that series.

By some authorities the age of these Gondwana rocks is supposed to be equivalent to that of the European formations which range between and include the Lower Oolite and the base of the Trias (Buntsandstein). By others the lower measures, including the coal, are believed to be palæozoic. The author proceeded to give an outline of the recent discussions on this subject, referring particularly to Mr. W. T. Blandford's judicial summary of the evidence in the lately issued 'Manual of the Geology of India.'

The distribution of the coal-bearing areas was then pointed out on a series of maps which were exhibited, and the number of distinct coal-fields was stated to amount to about thirty. Some details were then given regarding these fields, of which five only are worked at present, namely, Ranigunj, Kurhurbali, and Daltongunj in Bengal, and Mopani and Warora in the Central Provinces.

The total area of the Indian coal-fields is estimated by Mr. Hughes at upwards of 30,000 square miles. Three countries only contain larger areas, viz. United States 500,000, China 400,000, Australia 240,000.

The amount of coal raised in India varies a good deal from year to year with the supply of sea-borne coal in the market; this latter depends very much on the amount of tonnage available. Wars, famines, and other extraneous influences arising from time to time, bring a greater or less number of steamers and ships to the Indian ports, and these, in default of other cargo, often load up with coal.

During the last twenty years coal from Australia has been imported into India somewhat fitfully, and the supply from that source has now nearly dwindled to nothing.

In quality the Indian coals are inferior to the average of English and Australian; but they are capable of accomplishing good work in locomotives, and for this purpose they are largely employed on the main lines of railway in India. And were it not for the long and expensive land carriage from the fields in Bengal and the Central Provinces to the Bombay and Madras Presidencies there can be little doubt that they would be employed to the exclusion of all foreign sea-borne coal. Partly from this reason, and partly also from the impurity of the coals, they are not largely used in steamers, but even in this respect their employment is steadily increasing. Some of the steam companies rely chiefly upon them, and the swift opium steamers which run between Calcutta and China use Indian coal mixed in equal proportions with English.

The author proceeded to give further details as to the quality of the coal, stating that the anthracite varieties were rare, the general character being bituminous and the structure laminated—bright and dull layers alternating.

In Bengal the mines are worked by a number of different companies, some of

which conduct their operations with method and skill, and are financially in a very prosperous condition, others work in a more or less slovenly manner. In the Central Provinces one of the mines is worked by Government, but has not as yet repaid the outlay upon it.

In round figures it may be stated that at present 1,000,000 tons of coal are consumed in British India *per annum* in locomotives and factories, the quantity employed in the form of coke for domestic purposes being inconsiderable; and that of this 1,000,000 tons, about one-half is raised from Indian mines, the other coming from England, France, and Australia.

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6. *On Geological Episodes.* *By* J. F. Blake, *M.A., F.G.S.*

Geological nomenclature was first founded on the theory of universal deposits; then the idea of lateral changes was introduced with the necessary misuse of lithologically descriptive names; ultimately all deposits were seen to have their boundaries. Beds deposited in distinct areas can thus be proved only homotaxial, and these are by no means necessarily synchronous. The object of this paper is to show that a somewhat similar principle ought to govern all our geological classification. A single area is defined to be one over which we can trace one or more related formations consecutively, and which formations contain identical characteristic fossils. Deposits in single areas may be compared as to time and divided into life zones; but these in different areas are homotaxial only. In each single area the outlines and characters of the several deposits must first be determined and denoted accordingly.

In studying any group of rocks in a single area it is seen that some members have a much wider range than others. Such differences in range are accompanied by marked differences in character and point to differences in the circumstances of deposit. The wide-spread formation indicates uniform changes of level over the area and a mixture of deposits—such circumstances may be called normal. But mere local changes may bring more restricted areas into peculiar physical conditions. Such local changes may be called 'geological episodes,' and they will result in the formation of deposits of marked character easily distinguishable from the normal.

The first point is to determine the characters by which an episodal deposit may be differentiated from a normal one. The supreme test is that derived from its definition, *i.e.*, its local development; but if it be very small, it may be insignificant; if relatively very large, the distinction may be of no consequence. As a rule argillaceous rocks are normal, and arenaceous and calcareous episodal; but this is by no means universal. When the normal formation of a period is determined, the episodes are marked by their differing mineral nature. The two kinds of deposits may also be determined by the nature of their fossils, after we have first discovered what kinds of fossils are usually episodal. For this purpose those fossils which are found in all kinds of rocks, and therefore appear to have been indifferent as to their physical surroundings, may be called *invariant*, and those found only under particular conditions, and which change their locality as these conditions change, *covariant*. Invariants only are suited for zonal classification; covariants are characteristics of episodes. A table is drawn up showing the classes, families, and genera which may be covariant, according to the imperfect observations of the past. The chief covariants are a few Foraminifera—the sponges—a large number of Hydrozoa and Actinozoa, some Crinoids, the Blastoids, a few Lamellibranchs, and at least half the Gasteropod families.

The main proposition is that *similar, but distinct episodes, in a normal series of strata are neither necessarily nor probably of the same age.* The true method of geological classification is therefore to arrange only the normal deposits in a series by their stratigraphy and their invariant fossils, while the episodes are put in their place as such.

These doctrines applied to British strata yield the following results: No episodes are recognised in Cambrian or Pre-Cambrian rocks. In the Lower Silurian, the Durness limestone, the Llandeilo flags, the Bala limestone, and the Caradoc sandstone, and

the May Hill and Llandovery beds are characterised as such. Hence the term 'Caradoc' is inapplicable as a name for the normal portion of the series. The 'Colonies' of Barrande may be episodes recurrent on the same area. In the Upper Silurian, the Wenlock and Aymestry limestone, the Denbigh grits, and Tilestones are episodes. The Carboniferous series present us with the Coomhola grits, Burdie House limestone, Millstone, and Pennant grits, while the Mountain limestone is merely a gradually changing normal deposit. The episodes of the Permian are the fossiliferous limestone and underlying marl slate. The absence of the Muschelkalk from England is not regarded as due to its being an episode, but to our deposits as a whole being formed in a distinct area, the true episodes of the period being the Hallstadt, St. Cassian, and Dachstein beds. The Lias is remarkable for its great freedom from episodes, which accounts for the success of its zonal classification, the only exceptions being the Sutton series, and some of the Middle Lias rock beds. The lower Oolites, on the contrary, are almost entirely episodal, none of the beds having a wide range. The Yorkshire deposits were formed in a distinct area, and may cover the period of the Great Oolite as well as the Inferior Oolite, the deposits supposed to connect them with the latter being episodes. The rocks above the Cornbrash formed one connected series, as recognised by all German writers and some French, in which the Kelloway rock, the Corallian, and the Portland rocks are well-marked episodes in this country. It is therefore suggested that the term 'Middle Oolites' should be abolished from the classification of British strata, and the whole be known as Upper Oolites. The various episodes in this series on the Continent and in England will never be truly located until their real character is seen, and it has been by the study of these rocks that the doctrine of episodes has been suggested.

In the cretaceous series—the Wealden, the Tealby series, and parts of the Lower Greensand are episodal, the ironsands being the nearest approach to a normal formation. The Upper Greensands are also episodes; but the Chalk, though calcareous, is normal.

The Lower Tertiaries, like the Lower Oolites, scarcely present any normal deposits, the London Clay being, though argillaceous, episodal in character.

In the result, the series of sedimentary rocks should be represented not by so many parallel lines, but in many cases by lenticular masses, whose age is denoted by their position—according to a table which presents their true character. It is urged, therefore, that the names proposed—or else some better—be used to distinguish the different kinds of strata and fossils, in order to give definition and importance to truths which must have long been floating in the minds of geologists.

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7. *On the Keuper Beds between Retford and Gainsborough.* *By* F. M. Burton, *F.G.S.*

After describing the general position of the beds in relation to the Triassic system, and remarking on the absence of the Upper Mottled Sandstone, as well as the 'Muschelkalk,' in this part of England, the author described the various strata of the district, as shown on the line between Retford and Gainsborough, and pointed out the want of any division in the beds of the Lower Keuper Sandstone, as in other localities, and the absence of any boundary line between this series and the 'red marls' above. From the base of the Lower Keuper Sandstone, which rests directly on the 'pebble beds' at Retford, to the Keuper marls at Gainsborough, beds of light red clays, veins and blocks of gypsum and thin lines of ripple-marked sandstone occur throughout, and it is only when the highest beds of the Keuper marls are reached that any kind of stratification is discernible; bands of red, blue, and grey earths occurring just before the rocks dip under the Rhætic beds at Lea.

The author remarked also on the singular changes in the composition of the gypsum as the higher beds are reached. In the Lower Keupers at Retford, up to the 'red marls' at Gainsborough, this mineral is invariably fibrous or satiny in character; in the higher beds, however, it changes, at first, to rubbly patches, and, afterwards, to large granular or saccharoid blocks.

On the subject of life, the author was only able to record, from the beds in question, doubtful impressions of a shell, strongly resembling *Pullastra arenicola* of the Rhætics, and annelid burrows; but he had hopes, after more minute research, that further remains would be discovered in some of the more highly developed beds of the series, which would throw fresh light on their structure, and tend to establish their marine or estuarine origin.

From the fact of the same line of dip existing between the 'pebble beds' and the Lower Keuper Sandstone, notwithstanding the absence of the intervening Upper Mottled Sandstone and 'Muschelkalk,' the author inferred that the beds in question were deposited at a period of great and long-continued tranquillity, an inference which was borne out, he considered, in this part of England at least, by the position and contents, as well as the general configuration and line of dip, not only of the Rhætic beds above, but of the several Liassic, Oolitic, and Cretaceous strata beyond, and on through the Tertiary deposits to the present time.

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8. *On a Northerly Extension of the Rhætic Beds at Gainsborough.*
By F. M. Burton, *F.G.S.*

At the meeting of the British Association at Nottingham in 1866, the author announced the discovery of beds of the Rhætic age at Gainsborough, a full account of which will be found in the 'Quarterly Journal of the Geological Society for 1867.' These beds occur to the south of Gainsborough, on the Great Northern line between Doncaster and Lincoln, and were discovered through the lowering of the gradients of that line in 1866. The author has since found them in a cutting of the Manchester, Sheffield, and Lincolnshire Railway at Blyton, about five miles to the north of Gainsborough, where they must have been exposed since the making of that line in the year 1848, though hitherto they have remained unrecorded. Though much defaced by vegetation and the action of the weather, they appear to be of the same thickness as those at Lea, to the south of the town, and doubtless are of the same character and composition. The Keuper escarpment, in which these beds are situate, continues northward through Lincolnshire, east of the river Trent, to the south bank of the Humber, and extends on the other side into Yorkshire; and though, at present, these beds have escaped detection, the author had no doubt that, wherever the true junction of the Keuper marls and Lower Lias is laid bare, there beds of the Rhætic series will be found.

FRIDAY, AUGUST 22, 1879.

The following Reports and Papers were read:—

1. *Fifteenth Report on the Exploration of Kent's Cavern, Devonshire.* See Reports, p. 140.

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2. *Report on the Bone Caves of Borneo.* See Reports, p. 149.

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3. *On the Bone Caves of Derbyshire.*
By Professor W. Boyd Dawkins, *M.A., F.R.S.*

The author gave an account of discoveries in the bone caves in Derbyshire. The first cavern brought into light in Derbyshire, he said, was the famous one of

Wirksworth, about the year 1820, accidentally come upon in the workings of a lead mine. The finding in it of the remains of elephants, an almost perfect skeleton of the rhinoceros, and other remains of the same animal, established the fact of the existence of great extinct animals in that part of the world in olden days. In 1875 Mr. Mello found in the caves of Cresswell Crags bones of animals and remains of man's handiwork. The latter were of the highest interest, and led to an important chapter in the history of ancient man upon the earth. Last year his and the author's explorations were fitly ended by the working out of an entirely new cave down 'Mother Grundy's Parlour.' Among other remains discovered in the caves of Cresswell, Professor Dawkins named the hyena, the bison, the reindeer, the lion, the hippopotamus, and the bear. Besides these traces of the lower animals, there were in the lower strata rude and rough implements of quartzite, together with fragments of charcoal, proving that man was living in the district in those days. In the upper were more highly finished implements of flint, bone, and antler. The most important contribution, however, which had been offered to the history of man in this country was the discovery of a sketch of the horse engraved on a small fragment of bone. The subject of that engraving brought the cave-men into relation with those in Switzerland and France, for instance, where similar works of art, of a by no means low order, had been met with. Comparing the remains of implements, the rougher and the more highly finished specimens, they had evidence of the development of man in culture. In 1876 the author and Mr. Rooke Pennington explored a cave known as Windy Knoll, near Castleton, and came across a 'swallow' hole or chimney, containing vast quantities of the remains of the bison, the grizzly bear, and of some wolves and foxes. They also met with large numbers of the reindeer. He was able to make out an interesting point relating to the time of the year when some of these animals visited that part of the country; it being pretty clear the bison were there in the summer, and possibly in late spring; and the reindeer in winter. The last cavern that had been explored was discovered at Matlock Bath, in 1879, and the remains of animals found were of the same sort as those met with in Cresswell Crags. The next most important thing they would like to have settled was the age of those caverns, but that he looked upon as an impossibility. There was nothing to show that they existed before or during the Glacial period, and all the attempts which had been made to fix a date—outside the written record in the pages of the historian—he looked upon as mischievous, because they put before the minds of people who did not know, a definiteness with regard to geological events which those events did not possess.

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4. *Discovery of a Bone Cave near Cappagh, Co. Waterford.* *By* R. J. Ussher *and* Professor A. Leith Adams, *M.A., F.R.S.*

The above cave is in a limestone knoll that rises above a flat containing gravel. The sides of this flat are bounded by similar knolls and cliffs of limestone. The cave, which is tunnel-shaped, was, when discovered, nearly filled to its roof with stratified deposits. The *upper stratum* consisted of dark brown earth, closely packed, containing stones, both angular and worn, the latter chiefly sandstone. The numerous bones found in this stratum were yellow and recent-looking, and were, when not small, usually broken. They represented man, pig, horse, red deer, ox, goat or sheep, dog or wolf, fox, cat, marten, hare, rabbit, and birds. Charcoal occurred frequently. In the top stratum were also found, near the cave's mouth, a polished symmetrical celt of greenish stone, and near it a large flattened bead of a reddish transparent substance. At about fourteen feet inside the entrance was found a cut bone, of the size of a small gimlet-handle, with a hole drilled through it transversely, also the broken *shaft* of some carved implement with one barb or catch remaining; and at various points stones suited to the hand with ground surfaces, or with their edges chipped as if by use. In one rock crevice was found the shin-bone of some ruminant formed into a chisel, and in another a bone knife handle that had held an iron blade, and was ornamented with concentric circles on its four

sides. Both the latter articles may have got into the crevices where they were found from the top stratum. The *second stratum* was clearly defined from the first, was of a grey colour, very distinct, and contained much carbonate of lime that in places formed white seams in it. Much *charcoal* occurred in this stratum, and in part of the cave formed a faint black seam reposing on one of the white above mentioned; while underneath this more charcoal was found, not only in the grey stratum, but deep in that below it. The bones in this second stratum were generally blackened and had whitish dendritic markings. They represented man, ox, Irish elk, red deer, goat, pig, bear, dog or wolf, badger, fox, cat (?), marten, hare and rabbit. Remains of ox were not numerous, but those of Irish elk were abundant, and formed a leading feature of this stratum. They consisted chiefly of the small bones of the feet and leg-joints, and of the extremities of the marrow-bones (which were in all cases broken off), and splinters of the same. The metacarpal and metatarsal bones were split lengthways, often into narrow strips. One metatarsal was not only cleft in two through both extremities, but strips of bone which we found had been severed from it. Some of the Irish elk's bones appear to have been gnawed by some carnivoræ. Fragments of the antlers were also found. Along with a lot of the elk's remains (including the split metatarsal) was found a rounded bone, supposed to have been an awl, that was blackened like the neighbouring bones, and a worn stone with large perforations. Near these two was a bear's scapula; elsewhere a marine mussel-shell and a limpet occurred near human bones and charcoal in this stratum. In it were found, too, many stones, with their extremities chipped, some on both edges, as if by human use, and others that were ground down. Two fragments of coarse, hand-made pottery, blackened by fire on the concave side, were obtained either from the first or the second stratum. Under the second stratum was *crystalline stalagmite*, forming in the inner part of the cave a solid floor from $2\frac{1}{2}$ to $3\frac{1}{2}$ feet in depth, but in the outer part of the cave it had been broken up into blocks, which were enveloped in a pale sandy earth underlying the two upper strata. This sandy earth contained charcoal in several places and bones of bear, pig, deer, dog or wolf, and hare. The ursine remains were of very large individuals, equal to *Ursus spelæus* in size. On removing a floor of stalagmite that had not been broken up we found numerous bones of a large bear embedded in it, as well as the creature's mandible with the teeth, also teeth of deer; while embedded in the stalagmite and under it we got an astragal of Irish elk and a metacarpus of deer, short and stout, with the deep postern furrow of reindeer. The lowest stratum that reposed on the floor of the cave consisted of a coarse brown sand, mixed with gravel composed of fragments and pebbles of purplish, greenish, and yellow sandstone. This was united to the stalagmite on the line of contact.

No bones nor implements have yet been found in this lowest stratum.

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5. *On some remarkable Pebbles in the Boulder-clay of Cheshire and Lancashire.* By Charles Ricketts, *M.D., F.G.S.*

Erratic pebbles, ice-marked and otherwise eroded, occur abundantly in the Boulder-clay of Cheshire and Lancashire. There are others not so exceedingly infrequent which, with or without eroded surfaces, bear indications of weathering, but in such peculiar forms that it cannot have occurred under conditions existing in the British Isles at the present time. Some blocks of granite, volcanic rock, and sandstone are weathered all over, except at a necklike portion where they have been broken off as at a joint. Others of granite and trap are completely disintegrated, sometimes even throughout the whole mass, but each individual granule remains in its original position. Whilst other trappean blocks, generally partially striated, have portions of the surface roughened and honeycombed, the disintegrated material remaining attached in the form of a light green powder with minute fragments of the rock.

Carboniferous limestone pebbles are sometimes split apart, and are often affected by chemical action in various forms, generally since they have been glaciated; though some have subsequently been again exposed to glacier-friction. In a few

instances the whole surface is eroded, causing organisms to project in relief; more frequently a considerable area is affected whilst the remainder continues ice-scratched and intact; often hollows or channels have been formed, the other portions retaining the ice-marked surface. In some instances of impure limestone the carbonate of lime has been dissolved away in parts, leaving behind the insoluble sand or mud. A few blocks of carboniferous limestone not only bear marks of glacial erosion, but are covered with borings formed by marine animals; one example is likewise chemically eroded in channels.

Even some hard quartzites have not escaped weathering, as indicated by concealed joints and by channels hollowed on their surface.

Single fragments of glaciated pebbles of Silurian grits and slates are often found detached; a very few have the separate pieces lying at a short distance from each other; but in many, though quite separate, they are exactly in apposition, the pebble itself being broken into two or many parts.

From the examination of these different examples of glaciated and weathered pebbles, it may be inferred that they had formed portions of moraines on land, and, as a consequence of being there exposed repeatedly to successions of frost and thaw, have become thus weathered and split into fragments; those blocks of limestone which have been perforated by marine organisms bear evidence to their deposition, for a period, in a moraine accumulation beneath the sea. Subsequent to this recession an increase of snow-fall has caused an extension of the glaciers, which in its progress carried forward the accumulation into the sea, either directly, or by joining a main glacier from which the bergs have been broken off that conveyed away these boulders. As these erratics are common in the Boulder-clay at different horizons, it follows that there must repeatedly during a prolonged period have been a succession of instances of an advance and retreat of glaciers similar to what is recorded as taking place in Greenland.[1]

When examining moraine accumulations, pebbles of carboniferous limestone were obtained which were glaciated, weathered, and fractured, in a similar manner to some from the Boulder-clay; also similar fractured pebbles of Silurian grit and of Longmynd rock have been met with under the same conditions.

The existence of these pebbles both in moraines and also in the Boulder-clay illustrates what had been deduced from previous investigations in the Valley of the Mersey—that in Britain, during what is called the Glacial Period, 'the glaciers did not progress from an immense accumulation in the north, but were formed by the snow-fall in the respective valleys; being of such an extent only as might reasonably be considered due to the amount of deposition on their water-slopes.'[2]

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6. *On the Volcanic Products of the Deep Sea of the Central Pacific, with Reference to the 'Challenger' Expedition. By the* Abbé A. Renard *and* T. Murray.

The mineralogical and petrological researches on the sea-bottom of the Pacific area extending from the Sandwich Islands to the 30th degree of S. latitude, and having the Low Archipelago in its approximate centre, show that volcanic matter plays an important part there. It is present in the form of lapilli and of ashes spread in great abundance in the 'red clay.' These lapilli nearly all belong to the basaltic type, passing from the felspathic basalts to allied rocks in which the vitreous base assumes greater and greater development until it almost completely displaces the crystalline constituents of basalt. The fragments then become true glassy rocks of the basic series, in which are still found generally crystals of peridote, and numberless crystallites which are sometimes grouped in opaque granules or arranged regularly around the microlites of peridote. The forms of

[1] 'On the Fiords, &c. of Norway and Greenland,' by Amund Helland, Fellow of the University of Christiana.—*Quart. Journ. Geol. Soc.* vol. xxxiii. page 142.

[2] 'The Conditions existing during the Glacial Period,' &c., by Charles Ricketts.—Proc. Liverpool Geol. Soc., 1876–77.

these volcanic fragments, which are often coated with manganese, their association with volcanic ash, and their lithological constitution, shows them not to be derived from submarine flows of lava. They must rather be regarded as incoherent products—lapilli, the accumulations of which form in the Pacific a series of submarine tuffs.

One of the most remarkable facts elicited by the soundings in the Pacific is the large share taken in these sedimentary deposits by palagonites, quite identical in lithological characters with those of Sicily, Iceland, and the Galapagos Islands. One may, in fact, call them glasses of the basic series, playing the most important part among the sediments of the Pacific, and consisting either of sideromelane or decomposed into a red resinoid substance. The small lapilli, of 2 or 3 millimetres in diameter, are cemented by zeolites, the crystalline forms of which are those of christianite. It is enough to indicate the presence of the easily alterable basic glasses in order to show the source of the clayey matter with which they are associated, since it is known that wherever rocks of this type occur there also decomposition into clay is observable.

Among the minerals present in the volcanic ash are rhombic tabular crystals of plagioclase, augite, magnetite, with very little sanidine or hornblende. It is also remarkable to notice that in these deep-sea deposits quartz-grains are practically absent, in striking contrast to the coast deposits. It is not, however, this fact which is most worthy the attention of the Section, since it is not so unexpected as the formation of zeolites in the free state. The latter phenomenon takes place in the zone in question, where fibrous radiated spherules are found in the mud, 0·5mm. in diameter, and possessing the crystallographic character of christianite. Besides these zeolotitic globules there are other crystals of the same kind in the form of small prisms, not more than 0·026mm. in length, and occurring in such prodigious numbers that they form about a third of the red clay. Crystallographically these microlites must be referred to those forming the zeolotitic spherules. The authors regard them as belonging to one species. The formation of these zeolites and of the red clay in which they are developed is easily understood if one bears in mind the lithological nature of the above-described basic tuffs and of their decomposition-products.

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7. *On Ammonites and Aptychi.* *By* Charles Moore, *F.G.S.*

The author remarked that ammonites and aptychi are always found associated together in beds of secondary age, the latter organism never being met with beyond the range in time of that shell. The Aptycus is a peculiar triangular-looking body, usually bilobed, oftenest found loose in beds containing ammonites; but now and then in the outer chamber which that animal occupied during life. In structure it appears to be partly calcareous and partly corneous or horny.

Probably no organism has given rise to so much speculation or to more diverse views as to its zoological position. As far back as 1811 it was described as a bivalve shell and named *Trigonellites* by Parkinson, since which time it has been raised to the genera *Munsteria* and *Aptychus*, or considered by other authors as the plates of fishes, valves of cirripedes, internal bony plates of *Teudopsis*, the gizzards of ammonites, or a parasitic body attached thereto, and at last the general view arrived at and still entertained is that they are the opercula of ammonites.

The great variety of opinion thus entertained has arisen from the ammonite having become extinct, its only living analogue being the nautilus, and even of this genus only two or three examples with the animal have ever been obtained, one of which was dissected and described by Professor Owen, the aptychus in the ammonite being supposed to represent and to occupy the position of the fleshy hood in that shell.

In a paper published some years ago the author expressed a doubt as to the aptychus being an operculum, one reason being that it was not of sufficient size to cover the mouths of the shells in which they happened to be found, though for other reasons he had no doubt they were allied. He had now obtained new facts, which he would first give, and if he afterwards suggested any heterodox notion his justifi-

cation might be found in the views propounded by the many learned geologists who had preceded him.

The variety of forms which the aptychi assume appears to indicate almost a generic modification in the forms of the animals occupying the shells to which they belong. In the earliest known British ammonite (the *A. planorbis*) it is in one lobe only, with coarse concentric lines of growth, finer longitudinal striæ being visible by aid of the lens. In this species an inner layer is always black, as if stained by the pigment of cuttle fish, a circumstance seen also with some others from the upper lias. The author considered this might be due to the presence of animal matter to which the lobes were originally united. Although so many ammonites were known in the lower lias, he was only acquainted with the above species from this formation. In the upper lias they were oftenest found in connection with ammonites in a bed of about a foot in thickness, which he had called the Saurian and Fish bed, and in the clays which surround it. From this bed he had obtained microscopic ammonites, in which the aptychus might be seen far back in the outer chamber. They were found also in another remarkable way. Larger ammonites were deposited in the upper portion of this bed, but the shell itself has disappeared, leaving usually only the mould where it lay. It has not been washed out, but dissolved away, probably by carbonic acid. Strangely enough, in many examples the aptychus which was in the interior of the shell has not been affected by this action, and the siphuncular tube also has been left passing round its whorls where once were its many chambers. The fact that the aptychus belongs to the ammonite is shown by its presence in such minute specimens, by there never being more than one example, and by a special form being united to each species of ammonite. A remarkable point respecting the siphuncular tube is that it is not the mere tube as usually seen in other ammonites and nautili, but has an envelope of concentric layers surrounding it, increasing considerably its usual bulk. On examining the moulds of *Ammonites serpentinus* the author stated that he was surprised to find that their surfaces were covered by hundreds of thousands of minute scattered eggs, some apparently hatched, whilst other larger ovate bodies were possibly an advanced or metamorphosed form of the same animal. Amidst these scattered eggs there were also strings of similar eggs, though at times somewhat compressed and varying in size, lines of them lying together. In one instance the siphuncular tube passes over the aptychus, but they had not been noticed actually in connection. The question arose to the author, 'What have the aptychi and the tube to do with these eggs? Can either or both be an ovarian sac?'

Minute examinations of different forms of aptychi were then made, when it was found that in every instance they were almost entirely cellular, and the author was able to extract from them lines of cell-tubes, differing in scarcely any respect from the egg packets lying amidst the scattered eggs on the *Ammonites serpentinus* of the upper lias. Aptychus lævis of the Kimmeridge clay had yielded him great numbers of globular bodies which, though converted into iron pyrites, were undistinguishable from the eggs of the upper lias. In smaller numbers they were also found in *Aptychus lamellosus*. Both tubes and clusters of eggs were also obtained from the curiously formed *Aptychus Didayi*, whose curved and bold lines of growth gave a twisted form to the tubes. Microscopic sections of *Aptychus Didayi* and *A. lævis* showed what appeared to be eggs within their cellular tubes. The thinness of the structure of the upper lias species might seem almost to preclude this tubular character, but on examining unworn specimens it may be seen that the laminæ fold over like venetian blinds, and that their edges are fringed with tubes, coming to the surface, and which pass down obliquely through them. When the corneous layer which covers the concave side of the aptychus lobes is removed, myriads of minute cells are visible; these, as they pass through the body to the convex surface, bifurcate and enlarge.

The layer referred to is as thin as tissue paper; the author had been able to remove and preserve an example of this layer which, under the microscope, was a beautiful object; comparing small things with great it looked like the gnarled surface of a walnut-wood table, and showed the structure with openings in the centre of concentric circles passing round the tubes immediately below.

In his examination of the character of *Ammonites planorbis* and its aptychus, he had obtained curious and interesting results. He had found animal matter in the interior of the whorls of the shell, probably the equivalent of the siphuncular membrane as seen in the upper lias specimens. This contains thousands of rounded egg-like bodies in its substance.

All these facts were scarcely consistent with the idea that the aptychus was simply an operculum. He hoped to obtain further evidence before asserting positively that—possibly with the siphuncular tube—it is an ovarian sac, but the facts he had already worked out he thinks tend to that conclusion.

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8. *Notes on a Fossil Tree from the Upper Silurian of Ohio.* *By* E. W. Claypole.

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9. *On Ostracocanthus dilatatus, gen. et spec. nov. A fossil fish from the Coal-measures S.E. of Halifax, in Yorkshire.* *By* James W. Davis, *F.G.S.*[1]

The fossil fish remains so named were found in association with Ganoid and Elasmobranch fishes of the genera Megalichthys, Rhizodopsis, Cœlacanthus, and Gyracanthus, Ctenacanthus, and Pleuracanthus and several others, in a bed of cannel or stone coal, a few miles SE. of Halifax. This peculiar Ichthyodorulite is nearly $1\frac{1}{2}$ inches long, and $\frac{3}{4}$ inch broad at the base. From the base the diameter diminishes rapidly, and at $\frac{1}{2}$ an inch from the apex it is only ·15 of an inch. It remains about the same to the apex and ends in a blunt point. The upper part is smooth and covered with hard ganoine. The lower part is grooved longitudinally, increasing by bifurcation towards the basal end. Extending from the base, there is a mass of bony matter, joined to the spine; this is produced into two or three short denticles, it then becomes thinner, but again expands into a mass which may very well have served as the base of a second spine, if one was present. The only fossil spine bearing any resemblance to it is Byssacanthus of Agassiz. It is, however, only a superficial resemblance, and this one cannot be arranged under that genus. It also exhibits great similarity to the spines of Ostracion cornutus, the Trunk-fish, one of the Siluroid Teleosteans. Prof. Huxley has advanced several reasons for considering the Old Red species, Coccosteus, Pterichthys, &c. as nearly related to the modern Siluroids. It appears probable that the present specimen may be a representative of the Teleosteans during the coal period. It may be premature, considering the fragmentary nature of the specimen, to express such an opinion, but the spine and its attachments are so different to all other fossil fish remains which have been found in this country that I venture to suggest that such may be the case, and that further discoveries may place its relationship beyond doubt. I suggest the name *Ostracocanthus dilatatus*, as expressing its resemblance to that of Ostracion and indicating its wide and dilated base.

SATURDAY, AUGUST 23, 1879.

The following Papers and Report were read:—

1. *The Age of the Penine Chain.* *By* E. Wilson, *F.G.S.*

In this paper the author combated the generally accepted view of the post-Permian origin of the Penine chain, and contended for a pre-Permian upheaval.

[1] Published in the Proceedings of the Yorkshire Geol. and Polyt. Society, vol. vii. part 2, 1879.

In support of this opinion the following facts were cited: The Yorkshire coal-basin was admittedly pre-Permian, for north of Nottingham the magnesian limestone everywhere overlaps the coal measures; but the axis of this basin is parallel with and was evidently determined by the same series of movements that upraised the Penine chain. The Permians disappear on the west in approaching the Penine chain; in this direction also the marl slates attenuate, and the marl slates and magnesian limestone become more sedimentary, as if approaching a margin. Mountain limestone pebbles occur in Permian breccias on one or both sides of the Penine axis. Many fragments of carboniferous rocks occur in Lower Bunter Sandstone (breccias) on the borders of Notts and Derbyshire; but the author finds no fragments of Permian rocks in these breccias. No outliers of Permian rocks are found at any distance west of the magnesian limestone escarpment between Nottingham and Northumberland. The character and succession of the Permians on the two sides of the Penine chain are very dissimilar.

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2. *On the Foundation of the Town Hall, Paisley, with Notes on the Rocks of Renfrewshire.* *By* MATTHEW BLAIR.

Dolerite underlies the Boulder Clay there; it is probably the source of boulders of a similar rock which occur in the drift, and which have hitherto been considered as strangers to the district.

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3. *On the Deposit of Carbonate of Lime at Hierapolis, in Anatolia, and the Efflorescence of the Limestone at Les Baux, in Provence.* *By* DR. PHENÉ, *F.G.S., F.S.A.*

The author brought this subject forward as part of a duty which he considered ought to be recognised by travellers, of giving examples of matters of an exceptional character coming under their notice, the more so when, as in the present case, the particulars might be turned to purposes of utility. He had selected these two distant sites of calcareous deposit, not alone from their picturesque beauty and effect, but because they presented, he believed, the two most widely differing conditions of a somewhat similar material probably to be found. In the former case, the deposit of lime was so rapid that a large extent of country was covered with it. Its forms were eccentric and yet so beautiful that there was hardly any style of ornament the simulation of which would not be found in it. The Roman city, which took the place of a former Grecian one, was half submerged beneath a sea of rock of intense hardness, which, blocking up streets, temples, and vast arches, after reaching to a certain height, viz., the level of its source, ran over the natural aqueducts which it formed as it went, and began new ones lower down, which it again and again, as it reached the level of its source, repeated. He had counted six or eight of these natural walls nearly 50 feet in height, which, if they have been formed in consecutive order, give many hundred feet of deposit since the Roman occupation, perhaps within about 1,500 years. Part of the deposit was perfectly white, the other part quite black, giving the most singular appearance, as it looked like a snow drift lying in the intensely hot sun of Asia Minor, or a cataract of snow falling over black rocks, or a frozen cascade, which could only be illustrated in drawing by giving a representation in black and white, while the other parts of the landscape were in their usual natural colours. The Turks called it Pambuk Kalessi, or castle of cotton, from its whiteness. The destruction of this city by being hermetically sealed in stone, contrasts strangely with that of Eski-Hissar or Laodicea, on the opposite range of hills, which has had its stone edifices reduced by earthquake almost to a level. The hardness of this deposit, and the rapidity of its formation, contrasted strangely with the stone at Les Baux, which, though by no means soft to cut, had from its natural cavities suggested the idea to the founders of the city of excavating their houses in the sides of the rocks, quite as much as they built them outwards. This

rock, with little or no warning, disintegrates and discharges itself in efflorescence in the air, producing an effect as destructive to the city built there as in the former case, with quite as picturesque an effect, though from an exactly opposite cause. So much was being done now in ascertaining the component parts of stone for the purpose of hardening, as in the recent experiments on the Houses of Parliament, Cleopatra's Needle, and other well-known works, that it occurred to him that an analysis of these two rocks of similar component parts, but with varying conditions, would be well worth the attention of the chemist and the practical constructor.

The paper was illustrated with views of Hierapolis, &c.

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4. *Report on the Miocene Plants of the North of Ireland.*
See Reports, p. 162.

MONDAY, AUGUST 25, 1879.

The following Report and Papers were read:

1. *Sixth Report on the Conductivities of certain Rocks.*
See Reports, p. 58.

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2. *On some Broad Features of Underground Temperature.*
By Professor J. D. Everett, *F.R.S.*

The temperature at the surface of the ground is not sensibly influenced by the flow of heat upwards from below, but is determined by astronomical and atmospheric conditions.

The rate of increase in travelling downwards from the surface may conveniently be called the *temperature-gradient*, and averages about one degree Fahrenheit for fifty or sixty feet. This is about five times as steep as the temperature-gradient in the air.

If we draw isothermal surfaces for mean annual temperature in the ground, their form beneath mountains and valleys will be flatter than that of the surface above them. This is true even of the uppermost, and the flattening increases as we pass to lower ones, until at a considerable depth they become sensibly horizontal planes.

The temperature-gradient is consequently steepest beneath gorges, and least steep beneath ridges.

In a place where the surface of the ground and the isothermal surfaces beneath it are horizontal, the flow of heat will be vertical, and the same quantity of heat will flow across all sections which lie in the same vertical. In this case the flow across a horizontal area of unit size will be equal to the product of the *temperature-gradient* by the *conductivity*, if we employ the latter term in an extended sense, so as to make it include convection by the percolation of water, as well as conduction proper. It follows that, in comparing different strata lying in the same vertical, the gradient will vary in the inverse ratio of the conductivity. It seems probable that the same law of inverse proportion between gradient and conductivity holds approximately even when the strata compared are not in the same vertical, but are widely distant.

As regards the modes of observation which have been employed for the determination of gradients, shafts full of water, and wells of large diameter, afford so

much facility for equalisation of temperature by currents between the colder water above and the warmer water below, that they furnish no useful results. Even in bores of small diameter the same disturbing cause exists, and always makes the observed less than the true gradient.

Observations in mines will be vitiated by the presence of pyrites, which generates heat by its slow combustion, and are also liable to be vitiated by strong currents of air; but when they are taken at the newly-exposed face of a gallery which is being driven into the rock, care being taken to prevent strong air-currents at the place, and the surrounding ground not being too much honeycombed by previous excavations, good results may be obtained. A hole should be bored to the depth of about two feet in the newly-exposed face, the thermometer inserted, and the hole very tightly plugged with clay.

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3. *On the Botanical Affinities of the Carboniferous Sigillariæ.* *By* W. C. Williamson, *F.R.S., Professor of Botany in Owens College.*

The affinities of the Sigillariæ are still in dispute. The English palæo-botanists, apparently without exception, regard them as representing the highest modifications of the Lycopodiaceæ. The French palæontologists, and to some extent the American ones, elevate them to the Gymnospermous group. The question is of importance, both geologically and in reference to the problem of Evolution.

The only plants associated with the Sigillariæ in the Carboniferous forests, that exhibit any possible affinities with them, are the Lepidodendra on the one hand, and the Gymnospermous Dadoxylons and Cordaites on the other. Adopting the processes by which we ascertain the affinities of any newly discovered plant, we obtain results which appear to the author sufficiently conclusive. The old idea that Sigillariæ must have been large branchless stems must be abandoned. Various examples, such as *Lepidodendron Selaginoides*, which the French palæontologists claim to be Sigillarian, branch like other Lepidodendra; hence, whilst of some forms the branches are yet unidentified, this branchless state is most probably not a characteristic condition. Then the external leaf-scars of Sigillariæ exhibit nothing distinctive. Whilst in some types we have the vertical flutings of the stem and the linearly disposed leaf-scars of the Syringodendra, typical examples, such as *Sigillaria elegans* and *spinulosa*, along with many others of Brongniart's species, exhibit the diagonal arrangement of the leaf-scars characteristic of the unquestioned Lepidodendra. Then no one ventures to doubt the absolute identity of the cortical tissues in the two types of Lepidodendra and Sigillariæ. It is only when we reach the vascular axis that we find the supposed distinctions upon which the French botanists rely. These distinctions rest wholly upon the fact that, according to them, the Lepidodendra have a vascular axis in which the scalariform vessels are *not* arranged in any radial order, nor increased in bulk by any exogenous mode of growth, in the Sigillariæ, whilst the central part of the vascular area is occupied by a cylinder in all respects identical with that of the Lepidodendra, it is surrounded by an outer zone in which the vascular wedges are radially disposed, are separated by medullary rays, and have grown exogenously through the operation of a cambium-layer.

Whilst the author recognises the existence of these differences between the *Lepidodendron Harcourtii* on the one hand, and the so-called *Sigillariæ, elegans* and *spinulosa*, on the other, he denies that such differences are even generic, much less ordinal, since in several cases they can be shown to be due solely to age. Three states of *Lepidodendron Selaginoides* demonstrate this. In the one extreme form we have the central non-exogenous vascular axis, giving off foliar bundles, but unens closed by any exogenous zone. In the extreme opposite condition we find the foliar vascular bundles *apparently* given off from the exterior of an exogenous zone of the supposed Sigillarian type. In reality, these foliar bundles pass *from* the inner cylinder *through* the outer one, but only appear conspicuously in transverse sections at the exterior of this latter exogenous cylinder.

But the author's cabinet contains intermediate examples, in which the stems

exhibit the transition from the younger or non-exogenous to the more advanced or exogenous type. The cambium-layer has not developed throughout the entire circumference of the stem simultaneously, but has begun at one point, at the periphery of the non-exogenous cylinder, from which point it has extended slowly right and left, so as gradually to have crept round this inner vascular axis. In the specimens referred to, this exogenous cylinder is incomplete, exhibiting a crescentic form, the crescent being thickest at the centre, where the cambium-layer began to form, and gradually becoming thinner as we approach the extremities of its two lateral horns. This crescent, in different specimens, only embraces from one-third to two-thirds of the circumference of the non-exogenous axis; hence we have the anomalous condition of a plant one side of which is a Sigillaria and the other a Lepidodendron. Unless new features can be found other than what is often designated the Diploxyloid condition of the vascular axis, whereby to distinguish Sigillariæ from Lepidodendra, the above-named distinction must obviously be abandoned as having no generic value.

When a Lepidodendron was about to dichotomise, the vascular cylinder, as seen in transverse sections, splits into two horseshoe-shaped halves. The author exhibited specimens showing exactly the same conditions in a Sigillarian example. The invariable dichotomisation is in itself a Lycopodiaceous feature.

But one more remarkable fact is now demonstrated, which appears even yet more conclusive. M. Van Tieghem has carefully shown that the ultimate roots of the Lycopodiaceæ and of the Ophioglossæ have a structure which does not reappear in any other portion of the vegetable kingdom. In the Cycadeæ and Conifers, as well as in the other vascular cryptogams, the centre of each root is occupied by a cellular procambium enclosed within a pericambium or special cellular sheath. From this sheath, at points located at measured distances and in varying numbers, several, *but never less than two*, bundles of vessels are developed. The first formed vessels are of small size; but the more newly added ones increase in size as each bundle develops centripetally, until their converging lines meet in the centre of the procambium. But at the free ends of the peripheral portions of the roots, in the case of the Lycopodiums, and throughout their entire length in the Selaginellæ, *only one* such procambial bundle makes its appearance. When perfected this bundle exhibits a triangular form in the transverse section—the apex of the triangle, which always remains adherent to the pericambium, being occupied by the small and first formed vessels, whilst its broad base, composed of larger vessels, projects into the centre of the pericambium. These conditions reappear in the most exact manner in the rootlets of the *Stigmaria ficoides*, which all palæontologists who know anything about the matter now admit to be the roots of Sigillaria, as well as of Lepidodendron. This latter fact appears to the author, when combined with the numerous other features which the plants have in common, and with the absence of all real differences beyond such as are due to age, to be conclusive of at least the ordinal unity of the Lepidodendra and the Sigillariæ, and of the Cryptogamic character of both.

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4. *Evidence of the Existence of Palæolithic Man during the Glacial Period in East Anglia.* *By* S. B. J. Skertchly, *F.G.S.*—See Section D, Anthrop., p. 379.

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5. *The Geological Age of the Rocks of West Cornwall.* *By* J. H. Collins, *F.G.S.*

The author had examined during some years the stratified rocks of West Cornwall (marked as Devonian on the Government maps).[1] He discussed the determinations

[1] Some of the results of these observations have been already published. See 'The Hensbarrow Granite District,' Lake, Truro 1878, and *Trans. Royal Geol. Soc. of Cornwall*, vol. ix. 1879.

of fossils, especially the fish remains of Lantivet Bay and other districts, and contended that they partook more of the character of Upper Silurian than of Devonian, and showed that the stratigraphic evidence supported this conclusion.

He then showed that these rocks rested upon Lower Silurian rocks, which, however, covered a very much more extensive area than was shown on the official maps.

He also stated that still older rocks, of at present indeterminate age, came up from beneath the Lower Silurians at several points on the coast, and especially on the north, between Newquay and Perranporth, and suggested that the mica-schists of the Lizard were probably of the same age as these last-mentioned beds.

In conclusion, he drew attention to the vast periods of time indicated by the successive changes in direction of the folds in the strata, and to the vast amount of metamorphism to which all the rocks had been subjected. He also suggested that the rarity of fossils in many of the older beds might be due to the existence of a highly-mineralised condition of the waters through which the sediments fell, and which would cause those sediments to be charged with mineral matter. The subsequent segregation of these substances into later-formed fissures would account for the abundance and richness of the Cornish mineral lodes.

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6. *The Surface Rocks of Syria (suggested by the Quarries at Baalbek).* By James Perry, *B.E., County Surveyor, Roscommon.*

The country of Syria, where there are vast areas of irregular bare limestone rock, with alternations of heat and rains, and where the radiation into a clear sky at night is considerable, gives evidence of the action of a geological agent not taken much account of by persons who live in and visit countries where the hard rocks are mostly covered with a considerable thickness of soil, gravel, or clay.

I visited in the neighbourhood of Beyrout some quarries of a peculiar kind of sandstone. Beyrout is situated on a limestone coast, but to the south of the town there is a shifting field of sand which extends itself in varying directions as the prevailing winds vary, and it at the present time threatens to bury a considerable portion of the town, gradually advancing over a few additional houses each year. The sandstone in question is formed by a mixture of particles of limestone from the coast and the sand I have spoken of, which drifts and consolidates layer by layer into a series of low hillocks; these are one connected mass, and the mass is increasing in an evident manner under existing circumstances, although it is cut into caves and passages by quarrying the stone for building purposes. The stone is unequal in composition and appearance; in some places there is more carbonate of lime than in others; in parts the fantastical appearances of drifted snow are shown in miniature; and in many places the stone looks like rigid sponge. The mass is made solid by the action of rain water which dissolves the particles of carbonate of calcium, and, on being slightly elevated in temperature, re-deposits the carbonate of lime so as to cement together the particles of sand. It is this function of limestone in solution, affected by change of temperature distinct from *mere evaporation* (a cause usually supposed to effect more than I think it is capable of effecting), to which I wish to direct attention.

I have been at least a mile inside a stalactitic cavern whose floor was a river or lake, the atmosphere was continuously saturated, and if there be evaporation it is very slight indeed, where the stalactites were of huge proportions. The idea that these stalactites are formed when water which has filtered through hundreds of feet of limestone reaches an atmosphere slightly higher in temperature than the rocks, appears to me the correct one, although the rotten incrustations on the intrados of masonry bridges may be accounted for principally by evaporation.

I have repeatedly come to the assistance of housekeepers in limestone districts, by recommending a little hydrochloric acid to remove the deposit of limestone in glass bottles where water is kept for drinking purposes, and this is clearly a case of the kind of deposition in question.

Persons quarrying in Syria will find the good compact stone on the surface, and the explanation is the dissolving and depositing action I have described. This state of things is persistent all over the country, and in places I found a satisfactory explanation of a matter which had long puzzled me, viz., the formation of marble. When a bed of mud dries it shrinks and cracks; if the first set of cracks is filled up with mud of some different colour, of cohesion equal to or greater than that of the principal body of mud—you may imagine a second system of cracks filled with a slightly different colour, and so on—you will have such an appearance on making a section parallel to the surface as is shown in the diagram.* Now it is easy to see that if the process of solution and deposition set up by the action of rain water and sunshine tends to cover the country with a solid cake of crystalline limestone, expansion and contraction at the surface continually forms cracks which descend more or less deeply into the mass. According to this, from a plane surface there should proceed an irregularly columnar structure. This is observed in pieces of veined marble to some extent, but since the surface is not a plane surface but a changing surface, the columns intersect. Marbles of the kind I am describing are actually in course of formation at the surface of the ground. It is, however, quite plain that many marbles may have been subjected to heat metamorphic action after the veining has been produced.

It will be seen that all over the surface of a limestone country where the proper conditions exist, there may be formed a universal cake of limestone varying in thickness from 1 to 10 or 12 feet, and in some instances being 20 feet or more. Such a formation will produce large blocks of stone, and it is from such a formation the enormous blocks 14 × 14 × 64 at Baalbek have been quarried.

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7. *On certain Geological Facts observed in Natal and the Border Countries, during Nineteen Years' Residence. By the* Rev. George Blencowe.

The basal rocks of the coast are shale, with superincumbent sandstone, which has apparently received its present configuration from subsidence, as the strata dip at an inclination corresponding with the surface, and are cross-fractured. In this sandstone district a square mile of granite protrudes, with a few large loose blocks on one side and mounds of decomposed granite in the neighbourhood.

The sandstone is succeeded in the middle belt of Natal by deep beds of shale, in thick rusty strata, having in its higher portion blocks of sharp-angled trap scattered on the tops of the hills.

The northern portion of Natal is a white sandstone capped with trap, which in a high plateau of about fifty miles in length is undisturbed, but in the remaining portion has been scooped out by an abrading force, which has left ridges and isolated hills, corresponding in structure with the plateau, and like it with unbroken horizontal strata.

At the south-eastern extremity of this plateau there is a district, in and on the edge of Zululand, in which are evidences of violent volcanic action at a period intermediate between the deposit of the sandstone and the varied shale on which it rests. The two most conspicuous evidences of such action are an extinct mud volcano and the turning up beyond the perpendicular of a thick bed of vitrified shale.

In these newer sandstones coal abounds at various heights, and over a distance of several hundred miles. The water supply of this district is peculiar, coming from the surface of the basaltic trap, and not from the sandstone which underlies it.

The distinguishing peculiarity of this part of Africa is the presence of isolated hills of sandstone and trap on a high plateau, from which they rise 2,000 feet; from their correspondence of structure they have evidently at one time been united. The difficulty in accounting for their original construction and their present condi-

* A diagram was exhibited.

tion is the absence of all evidence of volcanic action in their neighbourhood, and of *débris*, the result of abrasion.

In the higher region petrified timber abounds, but no coal is found; while in the lower coal is abundant. The valley of the Tugela, which has been cut through the sandstone and trap to more than 2,000 feet in many places, reveals a depth of 1,500 feet of sandstone in diminishing strata, and occasionally shows basaltic trap at apparently long intervals of deposition.

TUESDAY, AUGUST 26, 1879.

The following Reports and Papers were read:—

1. *Fifth Report on the Underground Waters in the Permian, New Red Sandstone and Jurassic Formations.*—See Reports, p. 155.

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2. *Report on the Progress of the 'Geological Record.'*

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3. *On the replacement of Siliceous Skeletons by Carbonate of Lime.* *By* W. J. Sollas, *M.A., F.G.S.*

The author gave an account of certain calcareous fossil remains which exhibit, both in gross and minute structure, a close resemblance to certain existing siliceous sponges, and which differ widely from any known form of calcareous sponge. The natural inference appeared to be that the calcareous fossils were once siliceous sponges, the siliceous parts of which had undergone replacement by carbonate of lime. The alternative view that the fossils were originally calcareous, and that they represent an extinct group of Calcispongia, was discussed and shown to present far greater difficulties to the zoologist than the inferred mineral replacement offered to the chemist. Siliceous sponge spicules were stated to be remarkably soluble, yielding readily to the attacks of minute boring algæ, and undergoing solution in sea water soon after the death of the sponge which possessed them.

The Radiolaria of the Carboniferous limestone were likewise regarded as having once possessed a siliceous composition, which they had since exchanged for a calcareous one.

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4. *On Carboniferous Polyzoa and Palæocorynæ.* *By* G. R. Vine.

In this paper the author drew attention to the inadequate study that had been given to the Carboniferous Polyzoa. During the last few years vast masses of shales, containing polyzoal and other remains, have been brought to light, but none that he was acquainted with excelled in richness the Hairmyres *débris*. Here the specimens were well preserved, and the characters of the several species almost perfect.

The author considered that it was too early yet to draw up a classification that would be satisfactory to all naturalists. Attempts had been made to do this, but many details had to be furnished that could only be furnished after close study. Besides the *Fenestella*, other genera were alluded to in the paper, such as *Ceriopora Rhabdomeson, Hyphasmapora, Glauconome*, and *Diastopora*, but these are being studied analytically, and further details of their structure will be brought forward in a future report.

The *Palæocorynæ* were next alluded to, and the author said that he had identified all the species and forms of *Palæocorynæ* that had been figured by Dr. Duncan in his various papers. But the conclusion the author had arrived at was, that these so-called organisms were neither Hydroid, as was supposed by Dr. Duncan, nor foraminiferal, as was suggested by Dr. Allman—all the forms were referable to species of *Fenestella* and *Polypora*. Although this opinion was given with some confidence, the author was not prepared to say at present that the whole of Dr. Duncan's views were illusive. There can be no doubt but that the forms *P. scotica* were really infertile processes; but *P. radiata* had presented so many peculiar details to the author, that until he had satisfied himself as to the nature and purpose of this structure in the Polyzoary of the Polyzoa, he was not prepared to substantiate that Dr. Duncan had given an erroneous judgment. Although *P. radiata* may turn out to be after all a portion of *Fenestella*, and not a parasite.[1]

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5. *On the Classification of the British Pre-Cambrian Rocks.* By Henry Hicks, *M.D., F.G.S.*

The author divides the Pre-Cambrian rocks into four groups, under the following names, in ascending order: 1, *Lewisian*; 2, *Dimetian*; 3, *Arvonian*; and 4, *Pebidian*.

1. The *Lewisian*, so named by Sir R. Murchison to indicate the crystalline rocks of the Hebrides and North-Western Highlands of Scotland, is retained for the oldest group at present recognised in Britain, and largely developed in the Hebrides. It is found also in parts of the Malvern chain, the north-west of Ireland, and possibly also in Anglesey. The prevailing rocks in this group are massive gneisses, in which hornblende and red felspar are the chief ingredients, and quartz, chlorite, and mica but sparingly present. They are usually of a dusky red, grey, or dark colour. Sometimes almost a pure hornblende rock is found. The strike in these beds is usually E. and W., or some point between that and N.W. and S.E.

2. The *Dimetian*. This group is largely developed in Wales, as at St. David's, Caernarvon, Rhos Hirwain, and Anglesey. It has been found by Dr. Callaway in Shropshire, and I have recently seen it in the Malvern chain, especially in the Worcester Beacon. I noticed it also last year in large development at Ben Fyn, Loch Maree, and near Gairloch in Ross-shire; as well as at several other points in the North-Western Highlands of Scotland. The prevailing rocks in this group are granitoid and quartzose gneisses, with pinkish, flesh-coloured, or white felspar; and with limestones, micaceous, and, occasionally, chloritic and hornblendic bands. Brecciated beds also occur, in which bits of the older Lewisian gneiss are sometimes found. The strike is generally N.W. and S.E., or from this to N. and S. It evidently overlies the Lewisian unconformably in the areas where both have hitherto been found associated, and its highly quartzose character and lighter colour generally is in marked contrast to most of the members of that group.

3. The *Arvonian*. At the last meeting of the British Association I mentioned for the first time the discovery, or rather the separation, of this group. It is largely developed in Pembrokeshire and Caernarvonshire. It occurs also in Anglesey and Shropshire, and I have recently found it at the base of the Harlech group in the heart of the Harlech mountains. I have seen masses of it also from the Orkneys, and it probably occurs both in the Western Islands and in the Grampians of Scotland. It is the great Hälleflinta group of the Swedish geologists, and the Petrosilex group (Hunt) found so largely developed in North America. It is chiefly made up of quartzo-felspathic rocks, sometimes porphyritic, frequently brecciated; and of compact quartzose rocks or hälleflintas, which on microscopical examination

[1] Many particulars respecting *Palæocorynæ* will be published in *Science Gossip* for this year, and the greater bulk of the latter part of the above paper will be reproduced and fully discussed.—G. R. V.

have frequently the appearance of incipient gneiss. The strike is usually about N and S., and it overlies the Dimetian unconformably.

4. The *Pebidian*. This being the newest group in the Pre-Cambrian rocks, is the least altered in character, and most nearly approaches in strike to the overlying unaltered or Cambrian rocks. It resembles that group in many of its rocks, and on that account was for a time supposed to be identical with it, only that it had undergone local alteration. Now we know it underlies the latter unconformably, and that the apparent similarity in character is to be attributed to the fact that most of the Cambrian rocks were derived from the denudation of this group. That it was also in a high state of alteration before the Cambrian rocks were deposited upon it is evident from the fact that an abundance of pebbles and masses of it occur in the conglomerates at the base of the Cambrian. It consists for the most part of chloritic, felspathic, talcose and micaceous schistose rocks; alternating with massive and slaty greenstone bands, dolomitic limestone, serpentine, lava-flows, porcellanites, breccias, and conglomerates. It is traversed also frequently by dykes of granite, dolerite, &c. It is a group of enormous thickness, and is largely distributed over Great Britain. It occurs in many parts of Wales, in Shropshire, and in Charnwood Forest. I found it also last year in the North-West of Scotland, and have seen specimens of it, collected by Mr. James Thomson and others, from Islay and others of the Western Islands. Dr. Hunt recognised it also along the Crinan Canal, and in the vicinity of Lough Foyle in Ireland. It is probably represented in America by the Huronian group. The prevailing strike is N.N.E. to S.S.W., or from this to N.E. and S.W. The conglomerates at its base are largely made up of masses derived from the Arvonian; and it is undoubtedly at most of the points examined unconformable to that group.

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6. *On some further evidence relating to the range of the Palæozoic Rocks beneath the South-east of England.* *By* R. A. C. Godwin-Austen, *F.R.S., F.G.S.*—See Reports, p. 227.

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7. *On 'Culm' and 'Kulm.'* *By* G. A. Lebour, *M.A., F.G.S., Professor of Geology in the University of Durham College of Physical Science, Newcastle-on-Tyne.*

The word 'Culm,' locally denoting an impure, 'smutty' kind of coal in the West of England, is now applied by geologists to the series of beds containing this coal in Somersetshire and Devonshire. The horizon of these series is generally admitted to be that of the Millstone Grit, with, perhaps, the uppermost portion of the Upper Carboniferous Limestone series (*vide* Murchison, Renevier, &c.).

The German geologists, soon after the recognition of the Carboniferous age of the greater part of their so-called 'Jüngere Grauwacke' in 1838, adopted for it the term Culm (spelt *K*ulm), chiefly, it would appear, on the strength of the characteristic fossil *Posidonomya Becheri* which is common to these slaty rocks and to the Culm beds of Devon. Under this name of Kulm are now grouped a vast mass of carboniferous slaty beds, which strike across Europe from Eastern Silesia to the westernmost point of Portugal, and include most of the puzzling deposits scattered over Southern and Central France. These were formerly classed as belonging to the vague 'Terrain anthraxifère,' and as representing in age the entire Lower Carboniferous series, of which they must be regarded merely as a great altered shaly or non-calcareous facies.

The following table will show the inequality of the British Culm and of the Continental Kulm:—

<table>
<tr><th>General</th><th>W. Britain.</th><th>Germany</th></tr>
<tr><td colspan="3">Coal-Measures.</td></tr>
<tr><td>Millstone Grit</td><td>Millstone Grit</td><td>Flötzleehrer Sandstein</td></tr>
<tr><td rowspan="3">Upper Carboniferous Limestone
Lower Carboniferous Limestone
Ursian or Tuedian Beds</td><td>Culm</td><td>(unconformity frequently)</td></tr>
<tr><td rowspan="2">N.B.—This space is left without designation, because to fill it up would be to enter into the great Devonian question, which the writer wishes to avoid.</td><td rowspan="2">Kulm</td></tr>
<tr><td colspan="3">Devonian.</td></tr>
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It is too late in the day to expect that either term (Culm or Kulm) can now be abolished. But by adopting the Germanised form of the word for the Continental Younger Greywacké, and limiting the English 'Culm' to the local beds in Devon and Somerset, the very great difference in stratigraphical value of the terms may perhaps be brought home to the minds of students.

SECTION D.—BIOLOGY.

PRESIDENT OF THE SECTION—Professor ST. GEORGE MIVART, F.R.S., F.L.S., F.Z.S.

DEPARTMENT OF ZOOLOGY AND BOTANY.

THURSDAY, AUGUST 21, 1879.

The PRESIDENT delivered the following Address:—

IN responding to the honour which the authorities of the British Association have conferred in nominating me to fill this chair, I have deemed it best not to occupy your very valuable time with any matter of detail at which I may happen to have worked, but rather to offer to you a few remarks on questions which seem to me to have a general biological interest.

Last year my esteemed friend, Professor Flower, called your attention to the great name of LINNÆUS. I propose this year to refer to Linnæus' illustrious contemporary, BUFFON—not, however, in the character of a rival of Linnæus. Each was a man of genius, each did good work in his own way—work still bringing forth fruit. It must be admitted, however, that they were men of a very different stamp, and if it is necessary to express a relative judgment with respect to them, I should myself feel inclined to say that Buffon's mind had the greater aptitude for sagacious speculation, with an inferior power of acquiring and arranging a knowledge of facts of structure.

Various circumstances have concurred to favour our recollection of the merits of the great Swede, and to obscure those of the French naturalist. The well-earned fame of Linnæus is kept ever fresh in our memories by the necessarily frequent references to him in matters of nomenclature. On the other hand, not only are Buffon's claims on our esteem in no similar way brought before us, but those very speculative opinions of his, which are a merit in our eyes, have gained him disfavour with our immediate predecessors, whose opinions and sentiments we more or less inherit.

No one, however, can dispute Buffon's title to our grateful respect on account of the very powerful effect his writings had in stimulating men's love of nature, an effect which I think is not sufficiently appreciated.

It is fitting that I should call attention to his (once generally recognised) claims in this respect; since my own love of natural history is probably due to the circumstance that his great work was always accessible to me in my childhood, and was one of the earliest books with the pictures of which I was familiar.

Buffon was indeed Linnæus's contemporary, for the same year (1707) saw the births of both. In 1733 he was elected a member of the Academy of Sciences, and six years later was appointed superintendent of the *Jardin du Roi*,[1] which

[1] The Jardin du Roi was first instituted by Louis XIII. in 1628, and definitively established in 1635. It cannot be affirmed that Buffon enriched the incipient museum —the *Cabinet du Roi*—so much as might have been expected; although the skeletons which served for Daubenton's descriptions were, at least in many instances, preserved. It is to Geoffroy St.-Hilaire that the magnificent museum of the Jardin des Plantes, which now exists, is most indebted.

was the occasion of that work to which he is indebted for his fame, and to perfect which he displayed so much zeal in collecting specimens and in obtaining information respecting the various kinds of animals with which he became acquainted. His *Histoire Naturelle générale et particulière* began to appear in 1749, and in 1767 was published the fifteenth volume, which closed his history of mammals. Herein are contained those numerous anatomical illustrations (due, with their accompanying descriptions, to Daubenton) which have been again and again copied down to the present time. Next came nine volumes on birds, then his history of minerals, and, finally, seven supplementary volumes, the last of which appeared in 1789, the year after his death. His life was thus prolonged ten years beyond that of his illustrious contemporary, Linnæus.

Buffon can claim no merit as a classifier. With the exception of the Apes of the old and new worlds (which respectively fill the fourteenth and fifteenth volumes of his work), the beasts treated of are hardly arranged on any system, beyond that of beginning with the best known and most familiar—a system necessarily applicable to but a few forms.

But Buffon deliberately rejected the Linnæan classification—a grave error, certainly, yet one not altogether without excuse. Indeed, some of the objections he brought against that classification have considerable force. Such were his objections to the association of the hippopotamus, the shrew-mouse, and the horse in one order, and of the monkey and the manis in another.[1] What indeed could be more preposterous than the separation of the bat, *Noctilio leporinus*, from the other bats, and its association with the rodents, on the ground of its having (as supposed) only two incisor teeth above and two below?—an anomaly of arrangement of which you were reminded last year. It scarcely seems possible for the pedantry of classification to go further than this. Yet, perhaps, the association in one group of the walrus, the elephant, the ant-eater, the sloth, and the manatee, was hardly less unphilosophical. Moreover, zoologists should not forget, in blaming Buffon for his want of appreciation of the classification of Linnæus, that one great portion of that classification—the classification of plants—has been superseded by us. Had he lived to witness the publication of Jussieu's *Genera Plantarum*,[2] it might have given him a truer insight into biological classification, and have led him to endeavour to improve on Linnæus' system instead of only criticising it.

But it is Buffon's speculative views which have most interest for us. Those views exercised a very wide-spread influence in their day, though the time was not ripe for them. Indeed, it is far from improbable that writers whose speculations have been made public at a more propitious season, owe much to their comparatively forgotten predecessor.

Amongst Buffon's various speculations we might glance at his *Théorie de la terre* (put forth in the very first volume of his work), and at his *Epoques de la Nature*, which fills the fifth volume of his supplement. We might consider his speculations concerning the formation of mountain and valley by water, and the evidence that there was present to the ear of his imagination:—

> 'The sound of streams, which, swift or slow,
> Tear down Æolian hills and sow
> The dust of continents to be.'

That he saw, in thought, the projection of the planets from the sun's mass; the primitive fluidity of the earth, and the secular refrigeration of the sun. Such considerations, however, are foreign to this Section. I will therefore select two which are of biological interest.

In the first place I may refer to Buffon's speculations concerning ANIMAL VARIATION. In this matter Isidore Geoffroy St.-Hilaire has affirmed that Buffon stands to the doctrine of animal variability in a position analogous to that in which Linnæus stands to the doctrine of the fixity of species.

[1] 'Hist. Nat.' tome i. p. 39.
[2] This appeared in 1789.

Buffon, in his chapter on the animals of the Old and New World, remarks,[1] 'It is not impossible that the whole[2] of the New World's animals are derived from the same source as those of the old, whence they have descended.' . . . . 'Nature is in a state of perpetual flux.' In his chapter on the Degeneration of Animals[3] he sums up saying, 'After comparing all the animals, and arranging them each in their own group, we shall find that the two hundred kinds described here may be reduced to a small number of original forms, whence it may be all the rest have issued.'

As to the modes and causes of the origin of new forms, he entertained four connected opinions:

(1) He attributed much modifying efficacy to migrations;

(2) Also to the direct action of external conditions;

(3) He believed largely in the origin of new forms by degradation; and

(4) He regarded each animal as the manifestation of an individuating force, lying, as it were, at the root of the changes manifested by it.

The view that MIGRATION (with isolation) is a necessary antecedent to the origin of new species is one which has been advocated by a modern naturalist, Moritz Wagner;[4] who does not hesitate to affirm[5] that the formation of a really new species 'will only succeed when a few individuals, having crossed the barriers of their station, are able to separate themselves for a long time from the old stock.'

In support of his view the author brings forward a multitude of interesting facts, one of the most significant of which appears to me to be the following. It concerns Beetles of Tropical America of the genus *Tetracha*. In Venezuela (as also in the western part of Central America), he tells us, rivers flow partly through savannahs, where they have undermined the light tufaceous soil, forming deep beds with high precipitous banks. According to Professor Wagner, individual beetles from the highlands have thus been isolated, and in no longer time than has been required by the rivers to undermine the loose soil of the savannah, have given rise to a distinct species markedly different in form and colour. It is to similar causes—migration and complete isolation—that he traces the formation of distinct races of men: a formation he deems no longer possible, while the wide diffusion of mankind renders more and more difficult the evolution of new species of animals of any kind.

Instances which appear to support this view will readily suggest themselves to the naturalist—instances, that is, of forms which are both peculiar in structure and remote and isolated as to their habitat.[6] Thus for example, even in the group which structurally most resembles us, we have the Orang confined to very limited tracts in Borneo and Sumatra, and the Gorilla to a small portion of Western Africa. The Proboscis Monkey is found nowhere but in Borneo, while the singular ape named 'Roxellana' (from its wonderfully 'tip-tilted' nose) is confined to the lofty and isolated mountains of Moupin in Thibet. The very peculiar black ape (*Cynopithecus*) is limited to Celebes and Batchian, while the Baboon, which has the baboon character of muzzle most developed, was found at the extreme south of the African continent.

[1] *Op. cit.* vol. ix. p. 127.

[2] He thought that the American Jaguars, Ocelots, &c., and even the Peccary, were positive degradations of Old World forms. He thought that the Llama, the American Apes, Agoutis, and Ant-eaters might be examples of such forms; but the Opossum, Sloths and Tapirs he took to be original species. (See vol. xiv. pp. 272, 273.)

[3] Vol. xiv. p. 358.

[4] In a paper read before the Royal Academy of Sciences at Munich on March 2, 1868. This has been translated by Mr. James L. Laird, and published by Edward Stanford in 1873.

[5] *Op. cit.* p. 29.

[6] Isolation, it ought to be remembered, may take place as the result not only of changes in inorganic nature (such as the formation of islands, and the excavation of river beds), but also by the presence of enemies in intermediate tracts, by the circumstance that the food of the species is found only in certain restricted localities, and by whatever other causes determine the extinction of a species in a given place.

Again, if we take the group of Lemur-like animals (*Lemuroidea*) as having had their home and starting-point in or near their present head-quarters—Madagascar—then some of the most aberrant forms are those which must have migrated farthest. The character which is perhaps the most peculiar of any which the group presents, is the elongation of two of the ankle-bones, as we find it in the Madagascar genus *Cheirogaleus*. But this character is more exaggerated in migrants to Africa—the Galagos—and most so of all in the more isolated emigrant, the Tarsier, now found in Celebes and Borneo.

The sub-family of slow-lemurs (*Nycticebinæ*) would, on this view, seem to have migrated in opposite directions, as we find the slender slow-lemur (*Loris*) in Madras, Malabar, and Ceylon; the typical slow-lemur (*Nycticebus*) in South China, Borneo and Java; the Potto (*Perodicticus*) in Sierra Leone, and the Angwantibo (*Arctocebus*) in Old Calabar. Of these, it is the African forms which have the index-finger most atrophied—a tendency to its atrophy existing in the whole sub-family.

It would, of course, be very easy to multiply instances of the kind; but it would be also easy to cite a number of cases which appear to conflict with the view in question. Thus familiar to us as it is, few animals are more peculiar in structure than the common mole, which gives no present evidence of isolated origin; and the most aberrant of all bats, the Vampire (*Desmodus*), is rather widely distributed in South America. Again, with regard to the Lemur group, the most absolutely exceptional is the Aye-Aye (*Cheiromys*), which, on the hypothesis supposed, has remained persistently at the head-quarters of the group, i.e. in Madagascar.

Even, however, if no exception existed to the co-existence now of singularity of form and isolation and remoteness of situation, we could not safely draw any decided conclusion from such facts, because fossil remains show us that forms which have now a very limited distribution, were either widely spread in earlier times, or existed in regions very remote from those they now inhabit. Thus, in Eocene times there existed in Europe true opossums (now confined to America), Tapirs, and a form like the African Potto before mentioned. In Miocene times we had in Europe long-armed apes (creatures now found only in Eastern Asia), with the now exclusively African Secretary Bird and Cape Ant-Eater (*Orycteropus*). In the same period the Orang—or a nearly allied form—seems to have ranged over India. What are more emphatically old-world forms than the camel, horse and elephant, with the typical porcupine? Yet all these existed in America in Pliocene times. Did we know the Tapir in only one of the two widely-separated stations in which it dwells to-day, we might well deem its evolution to be due to migration and isolation. But we know from palæontology that it existed in Europe from the Eocene to the Pliocene period.

Such facts as these do not, of course, disprove the doctrine that migration and isolation are necessary antecedent conditions to specific genesis, but they show how much caution must be used in drawing the conclusion that they are necessary, from the distribution of animals much less likely to be found fossil than mammals are.

But an argument in favour of the views of Buffon and of Wagner may be obtained from our own species, which exhibits some singular coincidences between peculiarity of form and isolation. Among such instances may be mentioned the Tasmanians, the Andaman Islanders, and the Aïnos or Aborigines of Japan. One of the most striking examples is that of the Eskimo—a people presenting many peculiarities, some of which exaggerate the characters of the highest races of mankind. Thus, the pelvis differs from the European pelvis in an opposite direction to that by which the Negro pelvis differs from the European, and the same is the case with the proportions of the limbs, while the skulls of the Eskimo have the largest and narrowest nasal aperture of all races, being in this respect the very opposite to the Australians. The Eskimo have migrated eastwards, not reaching the south of Greenland till the fourteenth century, and the race characters are most marked in the most easterly tribes. These facts were brought forward by Professor Flower in his Hunterian lectures for the present year,[1] when he said that the characters of

[1] The lecturer also said: 'The large size of the brain of all the hyperborean races, Lapps as well as Eskimo, seems not necessarily to be connected with intellectual

this peculiar race 'must be attributed to those gradual modifications produced by causes at present little understood, by which most of the striking variations met with in the human species have been brought about—modifications more strongly expressed the more completely isolated the race has become, and the farther removed from its original centre of distribution.' I think, then, that though we have not data for conclusively answering the question as to how far migration (together with isolation) may be necessary for specific genesis, it is certain that it is of very great efficacy and importance, and that credit is justly due to Buffon for his early appreciation of its importance.

The next question to which I would advert is that concerning THE DIRECT ACTION UPON ORGANISMS, OF THE EXTERNAL CONDITIONS WHICH SURROUND THEM.

Buffon's belief was[1] that changes of specific form were brought about by change of temperature and climatic change generally, as well as by change of food.

The curious effects of stimulating food on colour—as of cayenne pepper with canaries, and hemp-seed with parrots—are notorious. The direct action of the environment on organisms has, I think, been of late somewhat undervalued. Amongst evidences in favour of its importance, I would refer to some of Mr. Alfred Wallace's observations.[2] He tells us that in the small island of Amboina, the butterflies (twelve species, of nine different genera) are larger than those of any of the more considerable islands about it, and that this is an effect plainly due to some local influence. In Celebes, a whole series of butterflies are not only of a larger size, but have the same peculiar form of wing. The Duke of York's island seems, he tells us, to have a tendency to make birds and insects white or at least pale, and the Philippines, to develop metallic colours, while the Moluccas and New Guinea seem to favour blackness and redness in parrots and pigeons. Species of butterflies which in India are provided with a tail to the wing, begin to lose that appendage in the islands, and retain no trace of it on the borders of the Pacific. The Æneas group of Papilios never have tails in the equatorial region of the Amazon Valley, but gradually acquire tails, in many cases, as they range towards the northern and southern tropics. Mr. Gould says that birds are more highly coloured under a clear atmosphere than in islands or on coasts—a condition which also seems to affect insects, while it is notorious that many shore plants have fleshy leaves. I need but refer to the English oysters mentioned by Costa, which, when transported to the Mediterranean, grew rapidly like the true Mediterranean oyster, and to the twenty different kinds of American trees, said by Meehan to differ in the *same manner* from their nearest European allies, as well as to the dogs, cats, and rabbits which have been proved to undergo modifications directly induced by climatic change.

It appears then that much may be said in favour of that direct effect of surrounding circumstances on Organisms in which Buffon believed.

Lastly, I would refer to Buffon's belief that new species have arisen by DEGRADATION. This again is an opinion which, after a period of disfavour, or at least of neglect, has been of late revived, and has acquired considerable influence. I may here refer to Anton Dohrn, who has recently advocated the very widely spread and effective action of degradation as a cause of specific change. It will, I think, be generally admitted that such exceptional Copepod crustaceans as *Tracheliastes* and *Lerneocera* are due to degradation, and the probability seems to me very strong that the Rhizocephala, at least many cirripeds, and the certoid worms, are also degraded organisms. Very interesting would it be to know whether existing Ascidians are also examples of degradation, as not a few zoologists now suppose; but most interesting of all is that parasite of cuttle fishes, *Dicyema*, the structure of which has been recently investigated by Professor Edward Van Beneden, and made the type of a new primary division of animals. Should this small worm-like organism hereafter turn out to be a degraded form, it will show what an extreme

development, but may have some other explanation not at present apparent.' I would suggest that in this case—as in the large brains of Cetaceans—it may be due to the need in their climate of generating much heat to sustain the necessary temperature of the body.

[1] *Op. cit.* vol. xiv. p. 317.

[2] See *Tropical Nature*, pp. 254–259.

degree of retrograde metamorphosis may occasionally be brought about. I think then that we have considerable ground for suspecting that degradation has acted much and widely in the field of Biology, and if so, Buffon is fairly entitled to a certain amount of esteem on account of the views he entertained with regard to it in so early a day and in so undeveloped a condition of zoological science. For it must not be forgotten that migration, the influence of external conditions, and degradation, are connected points: parts of one view. Degradation is most conspicuous under violent changes of condition (such as parasitism), while migration only acts by bringing organisms under new conditions.

These reflections lead me to urge upon such of my hearers as may have any unusual facilities for experimental investigation, a course of inquiry which seems to be very desirable.

What is needed in order to solve as far as possible the question of specific genesis, is a knowledge of the laws of variation, which must, I think, be deemed the true cause and origin of species.

We may, I think, accept as true two propositions:

(1) Animals may change in various ways, and amongst them, by degradation.

(2) Changes in the environment with isolation, induce and favour changes in form.

I would urge then that inquiries should be pursued in two directions simultaneously.

(A) There might be undertaken one set of inquiries to investigate the effects on different species of the same variations of environment.

(B) Other inquiries might be undertaken with a view to ascertaining the effects of different changes of environment on one and the same species. By series of experiments contrived with these ends in view, and carried on with various selected animals and plants which reproduce with rapidity, we may possibly be able to determine what to attribute to external influences (shown by such influences having the same effects on all), and what to the peculiar nature and innate powers and tendencies of different organisms—shown by the diverging reactions of the latter under the same changes in their environment.

I next desire to direct your attention to another matter treated of by Buffon—I mean THE RESEMBLANCES AND DIFFERENCES WHICH EXIST BETWEEN THE MIND OF MAN AND THE HIGHER PSYCHICAL FACULTIES OF ANIMALS.

This question is eminently a question of our own day, and one which I feel cannot but excite interest in this Section.

But its accurate investigation is attended with special difficulties, and amongst them are two temptations, which are apt to beset the inquirer:

(1) The first of these arises from the wide-spread love for the marvellous of whatsoever kind, and the tendency to inverted anthropomorphism.

(2) The other is the temptation to strain or ignore facts to serve a favourite theory.

As to the former of these dangers, I may perhaps be permitted to quote some remarks made by Mr. Chambers, approvingly cited by Professor Bain: 'There are two subjects where the love of the marvellous has especially retarded the progress of correct knowledge—the manners of foreign countries, and the instincts of the brute creation . . . . It is extremely difficult to obtain true observations' as to the latter 'from the disposition to make them subjects of marvel and astonishment.' . . . . 'It is nearly as impossible to acquire a knowledge of animals from anecdotes as it would be to obtain a knowledge of human nature from the narratives of parental fondness and friendly partiality.' This I believe to be most true, and that here the danger of mistaking inference for observation is exceptionally great. The inquirer ought not to accept as facts marvellous tales without criticism and a careful endeavour to ascertain whether the alleged facts are facts and not unconscious fictions.

As to the second danger, the lamented George Henry Lewes, whom no one can suspect of any hostility to Evolution in its most extreme form, remarks (in his posthumous work[1] just published) that the researches of various eminent writers

[1] *Problems of Life and Mind.* Third Series, 1879, p. 122.

on animal psychology have been 'biassed by a secret desire to establish the *identity* of animal and human nature,' and certainly no one can deny that those who do assert that identity are necessarily exposed to the temptation referred to. Of course persons who desire to disprove this identity are exposed to the opposite temptation; but it cannot be maintained that there is evidence of Buffon having been influenced by any such desire.

The obvious differences between the highest powers of man and animals have led the common sense of mankind to consider them to be of radically distinct kinds, and the question which naturalists now profess to investigate is whether this is so or not.

But we may doubt, whether many who enter upon this inquiry do not enter upon it with their minds already made up that no such radical difference can by any possibility exist. To admit it, they think, would be tantamount to admitting some non-natural origin of man, to accepting as a fact something not harmonising with our views as to nature generally, leading to we know not what results. To admit it, would be to deny the principle of continuity. There cannot, therefore, be any essential difference between man and brute, and their mental powers must be the same in kind. This, I think, is no unfair representation of the state of mind in which this question is very likely to be entered upon at the present time. Surely, however, if we profess to investigate a question, we ought in honesty to believe that there *is* a question to investigate, or else leave the matter to others; and if evidence should seem to show that 'intellect' *cannot* be analysed into sense, but is an ultimate, it ought to be accepted, at the least provisionally, as such, even at the cost of having to regard its origin as at present inexplicable. Can we explain the origin of 'motion'? But what rational man thinks of denying it on that account? Let us not reject anything, then, which may be evident, on account of certain supposed speculative consequences.

But that no such consequences as those referred to need follow from the admission of the radical distinctness of human reason, seems evident from the views of Aristotle. He certainly was free from theological prejudices or predispositions, and yet to his clear intellect the difference between the merely sentient and the rational natures was an evident difference, and the facts which are open to our observation are the same as those which presented themselves to his.

To enter on this inquiry with any fair prospect of success, it is not only necessary to guard against such temptations as these, but it is also necessary to be provided with a certain amount of knowledge of a special kind; namely, with a clear knowledge of what our own intellectual powers are. I conceive that, great as is the danger of exaggeration and false inference as to the faculties of animals, the danger of misapprehending and underrating our own powers is far greater.

Buffon held very decided views as to the distinctness of the mind of man from the so-called minds of animals. But an ingenious and gifted writer,[1] who has recently done good service in supporting Buffon's claims to greater consideration than he commonly receives, has, nevertheless, done him what I believe to be strange injustice in attributing to his great work an ironical character, and this in spite of Buffon's own protest[2] against irony in such a work as his. I cannot venture to take up your time with controversy on this subject; but, apart from Buffon's protest against 'équivoque,' it is incredible to me that he should have carried on a sustained irony through so voluminous a work—thus making its whole teaching absolutely mendacious. One remark of Buffon's, which has been strangely misinterpreted by this writer, I shall have occasion to notice directly; but I think it may suffice to clear Buffon's character from the aspersion of his admiring assailant, to point out that in the table of contents in the final volume of his 'History of Mammals'[3] (which table gives the pith and gist of his several treatises), he distinctly affirms the distinctions maintained in the body of his work.

The following were Buffon's views. In his 'Discourse on the Nature of Animals,'[4] he says, 'Far from denying feelings to animals, I concede to them

[1] Mr. Samuel Butler. See his *Evolution, Old and New*, Hardwicke & Bogue, 1879.
[2] *Op. cit.* tome i. p. 25.
[3] *Op. cit.* tome xv.
[4] *Op. cit.* vol. iv. p. 41.

everything, except thought and reflection' . . . . 'they have sensations, but no faculty of comparing them one with another, that is to say, they have not the power which produces ideas.' He is full of scorn[1] for that gratuitous admiration for the moral and intellectual faculties of bees, which Sir John Lubbock's excellent observations and experiments have shown to be indeed gratuitous. Speaking of the ape, most man-like (and *so* man-like) as to brain, he says:[2] 'Il ne pense pas: y a-t-il une preuve plus évidente que la matière seule, quoique parfaitement organisée, ne peut produire ni la pensée, ni la parole qui en est le signe, à moins qu'elle ne soit animée par un principe supérieur?'[3] Buffon has been accused of vacillation with respect to his doctrines concerning animal variation, but no one has accused him of vacillation with respect to his views concerning reason and instinct.

I come now to the passage which I said has been so strangely misunderstood. It is that in which he expresses his conviction that 'animals have no knowledge of the past, no idea of time, and consequently no memory.' But to quote this passage without explanation is gravely to misrepresent the illustrious French naturalist. Buffon was far from ignoring, indeed he distinctly enumerates the various obtrusive phenomena which often lead the vulgar to attribute, without qualification, both knowledge and memory to brutes. But, in fact, he distinguishes between[4] memory and memory. His words are: 'Si l'on a donné quelque attention à ce que je viens de dire, on aura déjà senti que je distingue deux espèces de mémoire infiniment différentes l'une de l'autre par leur cause, et qui peuvent cependant se ressembler en quelque sorte par leurs effets; la première est la trace de nos idées, et la seconde, que j'appellerais volontiers réminiscence[5] plutôt que mémoire, n'est que le renouvellement de nos sensations,' and he declares[6] true memory to consist in the recurrence of ideas as distinguished from revived sensuous imaginations.

This distinction is one which it is easy to perceive. That we have automatic memory, such as animals have, is obvious; but the presence of intellectual memory (or memory proper) may be made evident by the act of searching our minds (so to speak) for something which we know we have fully remembered before, and thus intellectually remember to have known, though we cannot now bring it before our imagination.

As with memory, so with other of our mental powers, we may, I think, distinguish between a higher and a lower faculty of each; between our higher, self-conscious, reflective mental acts—the acts of our intellectual faculty—and those of our merely sensitive power. This distinction (to which I have elsewhere[7] called attention) I believe to be one of the most fundamental of all the distinctions of biology, and to be one the apprehension of which is a necessary preliminary to a successful investigation of animal psychology. It is, of course, impossible for us thoroughly to comprehend the minds of dogs or birds, because we cannot enter into the actual experience of such animals, but by understanding the distinction between our own higher and lower faculties,[8] we may, I think, more or less approximate to such a comprehension.

[1] *Op. cit.* tome iv. p. 91.

[2] *Op. cit.* tome xiv. p. 61.

[3] Mr. Butler cites objections brought forward in a certain passage (from pp. 30 & 31, vol. xiv.), as if they were Buffon's own. But they are the objections of an imagined opponent whose views Buffon himself combats. It is worthy of note that Buffon long anticipated our contemporaries with respect to man's place in nature in so far as concerns his mere anatomy. For he did not hesitate to affirm that the Orang differs less from us structurally than it differs from some other apes.

[4] *Op. cit.* tome iv. p. 60.

[5] Here he follows, without citing, the old distinction of Aristotle between memory and reminiscence.

[6] *Op. cit.* tome iv. p. 56.

[7] *Lessons from Nature*, Murray, 1876, p. 196.

[8] Certain writers (as, for example, Professor Ewald Hering, of Prague) have used the word 'memory' to denote what should properly be called 'organic habit,' i.e. the power and tendency which living beings have to perpetuate, in the future,

It may, I believe, be affirmed that no animal but man has yet been shown to exhibit true concerted action, or to express by external signs distinct intellectual conceptions—processes of which all men are normally capable. But just as some plants simulate the sense-perception, voluntary motions and instincts of animals, without there being a real identity between the activities thus superficially similar, so there may well be in animals actions simulating the intellectual apprehensions, ratiocinations, and volitions of man without there being any necessary identity between the activities so superficially alike. More than this, it is certain *à priori* that there must be such resemblance, since our organisation is similar to that of animals, and since sensations are at least indispensable antecedents to the exercise of our intellectual activity.

I have no wish to ignore the marvellous powers of animals or the resemblance of their actions to those of man. No one can reasonably deny that many of them have feelings, emotions and sense-perceptions similar to our own; that they exercise voluntary motion and perform actions grouped in complex ways for definite ends; that they to a certain extent learn by experience, and can combine perceptions and reminiscences so as to draw practical inferences, directly apprehending objects standing in different relations one to another, so that, in a sense, they may be said to apprehend relations. They will show hesitation, ending apparently, after a conflict of desires, with what looks like choice or volition, and such animals as the dog will not only exhibit the most marvellous fidelity and affection, but will also manifest evident signs of shame, which may seem the outcome and indication of incipient moral perceptions. It is no great wonder, then, that so many persons, little given to patient and careful introspection, should fail to perceive any radical distinctions between a nature thus gifted, and the intellectual nature of man.

But, unless I am greatly mistaken, the question can never be answered by our observations of animals, unless we bear in mind the distinctions between our own higher and lower faculties.

Now I cannot here even attempt to put before you what I believe to be the true view of our own intellectual processes. Still I may, perhaps, be permitted to make one or two passing observations.

Everybody knows his own vivid feelings (or sensations), and those faint revivals of feelings, simple or complex, distinct or confused, which are imaginations and emotions; but the same cannot be said as to thought. Careful introspection will, however, I think, convince anyone that a 'thought' is a thing widely different from an 'imagination'—or revival of a cluster of faint feelings. The simplest element of thought seems to me to be a 'judgment,' with an intuition of reality concerning some 'fact,' regarded as a fact real or ideal. Moreover, this judgment is not itself a modified imagination, because the imaginations which may give occasion to it persist unmodified in the mind side by side with the judgment they have called up. Let us take, as examples, the judgments 'That thing is good to eat,' and 'Nothing can be and not be at the same time and in the same sense.' As to the former, we vaguely imagine 'things good to eat,' but they exist *beside* the judgment, not *in* it. They can be recalled, compared, and seen to co-exist. So with the other judgment, the mind is occupied with certain abstract ideas though the imagination has certain vague 'images' answering respectively to 'a thing being' and 'a thing not being,' and to 'At the same time' and 'in the same sense;' but the images do not *constitute* the judgment itself any more than human 'swimming' is made up of 'limbs and fluid,' though without such necessary elements no such swimming could take place.

This distinction is also shown by the fact that one and the same idea may be suggested to, and maintained in the mind by the help of the most incongruous images, and very different ideas by the very same image. This we may see to be the case with such ideas as 'number,' 'motion,' 'identity,' &c.

effects wrought on them in the past. But to call such action as that by which a tree as it grows preserves the traces of scars inflicted on it years before, 'memory,' is a gross abuse of language—a use of the word as unreasonable as would be the employment of the word 'sculptor' to denote a quarryman, or 'sculpture' to indicate the fractures made in rocks by the action of water and frost.

But the distinctness of 'thought' from 'imagination' may perhaps be made clearer by the drawing out fully what we really do when we make some simple judgment, as, e.g., that 'a negro is black.' Here, in the first place, we directly and explicitly affirm that there is a conformity between the external thing, 'a negro,' and the external quality, 'blackness'—the negro possessing that quality. We affirm secondarily and implicitly a conformity between the two external entities and the two corresponding internal concepts. And thirdly, and lastly, we also implicitly affirm the existence of a conformity between the subjective judgment and the objective existence.

All that it seems to me evident that sentience can do, is to associate feelings and images of sensible phenomena, variously related, in complex aggregations; but not to apprehend sensations as 'facts' at all, still less as internal facts, which are the signs of external facts. It may be conceived as marking successions, likenesses and unlikenesses of phenomena, but not as recognising such phenomena as *true*. Animals, as I have fully admitted, apprehend things in different relations, but no one that I know of has brought any evidence that they apprehend them *as* related, or their relations *as* relations. A dog may feel shame, or possibly (though I do not think probably) a migrating bird may feel agony at the imagination of an abandoned brood; but these feelings have nothing in common with an ethical judgment, such as that of an Australian, who, having held out his leg for the punishment of spearing, judges that he is wounded more than his common law warrants.

Animals, it is notorious, act in ways in which they would not act had they reason; while, as far as I have observed or read, all they do is explicable by the association of sensations, imaginations, and emotions, such as take place in our own lower faculties. We cannot, of course, prove a negative, but we have no right to assume the existence of that for which there is no evidence, without which all the facts can be explained, and which if it did exist would make a multitude of observed facts impossible. Apes (like dogs and cats) warm themselves with pleasure at deserted fires, yet, though they see wood burning and other wood lying by, though they have arms and hands as we have and the same sensient faculties, they have never, so far as I know, been recorded to have added fuel to maintain their comfort. Swallows will continue to build on a house which they see has begun to be pulled down, and no animal can be shown to have made use of antecedent experience to *intentionally* improve upon the past.

If, on the other hand, animals were capable of deliberately acting in concert, the effects would soon make themselves known to us so forcibly as to prevent the possibility of mistake.

Mr. Lewes has not hesitated to affirm[1] that 'between animal and human intelligence there is a gap which can only be bridged over by an addition from without,' and he also says:[2] 'The animal world is a continuum of smells, sights, touches, tastes, pains, and pleasures: it has no objects, no laws, no distinguishable abstractions, such as self and not self.' . . . . . 'If we see a bud, after we have learned that it is a bud, there is always a glance forward at the flower and backward at the seed . . . . . but what animal sees a bud at all except as a visible sign of some other sensation?' As a friend of mine, Professor Clarke,[3] has put it: 'In ourselves sensations presently set the intellect to work; but to suppose that they do so in the dog is to beg the question that the dog has an intellect. A cat to bestir itself to obtain its scraps after dinner, need not entertain any *belief* that the clattering of the plates when they are washed is usually accompanied by the presence of food for it, and that to secure its share it must make certain movements; for quite independently of such belief, and by virtue of mere association, the simple objective conjunction of the previous sounds, movements, and consequent sensations of taste, would suffice to set up the same movements on the present occasion.' Let certain sensations and movements become associated, and then the former need not be noted: they only need to exist for the association to produce its effects, and simulate apprehension, deliberation, inference, and volition. 'When

[1] *Problems of Life and Mind*, vol. i. p. 156.
[2] L. c. p. 140.
[3] *Questions on Psychology*, p. 9.

the circumstances of any present case differ from those of any past experience, but imperfectly resemble those of many past experiences, parts of these, and consequent actions, are irregularly suggested by the laws of resemblance, until some action is hit on which relieves pain or gives pleasure. For instance . . . . . let a dog be lost by his mistress in a field in which he has never been before. The presence of the group of sensations which we know to indicate his mistress is associated with pleasure, and its absence with pain. By past experience an association has been formed between this feeling of pain and such movements of the head as tend to recover some part of that group, its recovery being again associated with movements which, *de facto*, diminish the distance between the dog and his mistress. The dog, therefore, pricks up his ears, raises his head and looks round. His mistress is nowhere to be seen; but at the corner of the field there is visible a gate at the end of a lane which resembles a lane in which she has been used to walk. A phantasm (or image) of that other lane, and of his mistress walking there, presents itself to the imagination of the dog; he runs to the present lane, but on getting into it she is not there. From the lane, however, he can see a tree at the other side of which she was wont to sit; the same process is repeated, but she is not to be found. Having arrived at the tree he thence finds his way home.' By the action of such feelings, imaginations, and associations—which we know to be *veræ causæ*—I believe all the apparently intelligent actions of animals may be explained without the need of calling in the help of a power, the existence of which is inconsistent with the mass, as a whole, of the phenomena they exhibit.

But if there *is* a radically distinct intellectual power or force in man, is such a distinction of kind so isolated a fact as many suppose? May there not exist between the forces which living beings exhibit other differences of kind?

Each living being consists of an aggregation of parts and functional activities which are evidently knit together into a unity. Each is somehow the seat or theatre of some unifying power or condition which synthesises their varied activities, and is a PRINCIPLE OF INDIVIDUATION. This seems certainly to have been the opinion of Buffon, and it is to this opinion that I referred in speaking of the fourth cause to which he attributed the changes in organic forms. And to me it seems that we must admit the existence of such a living principle. We may analyse the activities of any animal or plant, and by consideration of them separately find resemblances between them and mere physical forces. But the *synthesis* of such forces as we find in a living creature is certainly nowhere to be met with in the inorganic world.

To deny this would be to deny the plainest evidence of our senses. To assert that each living body is made up of minute independent organisms, each with its own 'principle of individuation,' and without subordination or co-ordination, is but to multiply difficulties, while such a doctrine conflicts with the evidence of our own perceptions, which lead each of us to regard himself as one whole—a true unity in multiplicity.

The existence in each creature of a peculiar, co-ordinating, polar force, seems to be specially pointed to by the phenomena of serial and bilateral symmetry, by the symmetrical character of certain diseases, by the phenomena of monstrous growths, and by the symmetrical beauty of such organisms as the Radiolarian Rhizopods.

It also seems to me to be made evident, by the various activities of each animal, which are, as a fact, grouped in one in mutual interaction—an organism having been described by Kant as a creature, the various parts of which are reciprocally ends and means.

I think now I hear the exclamation—This is 'Vitalism!' while some of my hearers may deem these matters too speculative for our Section.

But consciously or unconsciously, general conceptions of the kind exist in the minds of all biologists, and influence them in various ways, and their consideration, therefore, can hardly be out of place here; while as to 'Vitalism,' I am convinced I shall not be wasting your time in endeavouring to remove a wide-spread misconception.

The 'Vitalism' which is so reasonably objected to, is that which supposes the existence in each living creature of some separate entity inhabiting the body

—an extra-organic force within the living creature, and acting by and through it, but numerically distinct from it. But the view which I venture to put before you as that which is to my judgment a reasonable one, is that of a peculiar form of force which is *intra-organic*, so that it and the visible living body are one thing, as the impress on stamped wax and the wax itself are one, though we can ideally distinguish between the two. It is, in fact, a mode of regarding living creatures with prime reference to their activities rather than to their material composition, and every creature can of course be regarded either statically or dynamically. It is to regard any given animal or plant, not as a piece of complex matter played upon by physical forces, which are transformed by what they traverse, but rather as a peculiar immanent principle [1] or form of force (whensoever and howsoever arising), which for a time manifests itself by the activities of a certain mass of complex material, with which it is so entirely one that it may be said to constitute and *be* such animal or plant much rather than the lump of matter which we can see and handle can be said to constitute such animal or plant. On this view a so-called 'dead bird' is no bird at all, save by abuse of language, nor is a 'corpse' really a 'dead man'—such terms being as self-contradictory as would be the expression 'a dead living creature.'

Thus the real essence, the substantial constituent, of every living thing is something which escapes our senses, though its existence and nature reveal themselves to the intellect.

For of course our senses can detect nothing in an animal or plant beyond the qualities of its material component parts. But neither is the function of an organ to be detected save in and by the actions of such organ, and yet we do not deny it its function or consider that function to be a mere blending and mixture of the properties of the tissues which compose it. Similarly it would seem to be unreasonable to deny the existence of a living principle of individuation because we can neither see nor feel it, but only infer it. This power or polar force, which is immanent in each living body, or rather which is that body living, is of course unimaginable by us, since we cannot by imagination transcend experience, and since we have no experience of this force, save as a body living and acting in definite ways.

It may be objected that its existence cannot be verified. But what *is* verification? We often hear of 'verification by sensation,' and yet even in such verification the ultimate appeal is not really to the senses, but to the intellect, which may doubt and which criticises and judges the actions and suggestions of the senses and imagination. Though no knowledge is possible for us which is not genetically traceable to sensation, yet the ground of all our developed knowledge is not sensational, but intellectual, and its final justification depends, and *must* depend, not on 'feelings,' but on 'thoughts.' I must apologise to such an audience as that I have the honour of addressing for expressing truths which, to some of my hearers, may appear obvious. I would gladly suppress them as superfluous did not my own experience convince me that they are not superfluous. To proceed: 'Certainty' does not exist at all in *feelings* any more than doubt. Both belong to thought only. 'Feelings' are but the materials of certainty, and though we can be perfectly certain about our feelings, that certainty belongs to thought and to thought only. 'Thought,' therefore, is our absolute criterion. It is by self-conscious thought only

[1] The word 'principle' has been used to denote that activity which, together with material substance, constitutes a living creature, because that word calls up a less sensuous, and therefore less misleading, phantasm than any other. The old term ψυχή, or soul, has in modern times come to be associated with the idea of a substance numerically distinct from the living body, and capable of surviving the destruction of the latter. But as structure and function ever vary together (as do the convexities and concavities of a curved line), so 'the principle of individuation' or soul of an animal or plant and its material organisation must necessarily arise, vary, and be destroyed simultaneously, unless some special character, as in the case of man, may lead us to consider it exceptional in nature. Even in man, however, there seems no adequate reason for believing in the existence of any principle of individuation, save that which exerts its energy in all his functions, the humblest as well as the most exalted.

that we know we have any feelings at all. Without thought, indeed, we might feel, but we could not know that we felt or know ourselves as feeling. If then we have *rational* grounds for the acceptance of such a purely intellectual conception as that of an immanent principle as the essence of each living creature, the poverty of our powers of imagination should be no bar to its acceptance. We are continually employing terms and conceptions—such, e.g., as 'being,' 'substance,' 'cause,' &c.—which are intelligible to the intellect (since they can be discussed), though they transcend the powers of the imagination to picture.

It seems to me that the spirit which would deny such realities is the same spirit which would deny our real knowledge of an external world at all, and represent any material object as 'a state of consciousness,' and at the very same time represent 'a state of consciousness,' as the accompaniment of a peculiar state of a material object —the body.[1] This mode of representation may be shortly, but not unjustly, described as a process of intellectual 'thimble-rigging,' by which the unwary spectator is apt to be cheated out of his most valuable mental possession—his rational certainty.

The same spirit asserts that our psychical powers never themselves enter into the circuit of physical causation, and yet few things would seem more certain to a plain man than that (supposing him to have received a message saying his house is on fire) it is his *knowledge* of what has been communicated which sets him in motion. To deny this is to deny the evident teaching of our consciousness. It is to deny what is necessarily the more certain in favour of what is less so. If I do not know this I know *nothing*, and discussion is useless. As a distinguished writer has said: 'That we are conscious, and that our actions are determined by sensations, emotions, and ideas, are facts which may or may not be explained by reference to material conditions, but which no material explanation can render more certain.' The advocate of 'Natural Selection' may also be asked, How did knowledge ever come to be, if it is in no way useful, if it is utterly without action, and is but a superfluous accompaniment of physical changes which would go on as well without it?

As we may be confident that thought not only is but also acts, as well as that there are things which are not psychical, but which are physical; so I would urge that the conception of living things, which I venture to put before you, is one which may be rationally entertained.

Assuming for the moment and for argument's sake that it may be accepted, what light does our knowledge of ourselves throw upon the intimate life-processes of lower organisms? We know that with us a multitude of actions, which are at first performed with consciousness, come to be performed unconsciously; we know that we experience sensations[2] without perceiving them; we know also that countless organic activities take place in us under the influence and control of the nervous system, which either never rise into consciousness at all, or only do so under abnormal conditions. Yet we cannot but think that those activities are of the same generic nature, whether we feel, perceive, or attend to them or not. The principle of individuation in ourselves, then, evidently acts with intelligence in some actions, with sentience in many actions, but constantly in an unperceived and unfelt manner. Yet we have seen it undeniably intervene in the chain of physical causation.

[1] Those who deny that we have a real power of perceiving objects, refute themselves when they speak of 'purely physical changes,' or of anything 'physical' of which feelings are but the 'accompaniment' or 'subjects.' For according to them 'matter' is but a term for certain 'states of consciousness,' while they represent each state of consciousness as a function of matter. According to this, let a represent a 'state of consciousness, and b a physical state.' Then a sensation and its physical accompaniment may be represented by the symbol $a + b$. But a physical state is itself but a state of consciousness with its objective correlate, and is, therefore, $a + b$. We thus get an equation infinitely more erroneous than $b = a + b$, because the b of the $a + b$ is itself ever again and again $a + b$.

[2] As when having gazed vacantly through a window we revert to the pages of a manuscript we may be writing and see there the spectra of the window bars we had before unconsciously seen. Here the effect on the organism must have been similar to what it would have been had we attended to it—i.e. it was an unfelt sensation.

An animal is an organism all the actions of which are necessarily determined by the adjustments of its various organs, and by its environment. But even its sensations cannot be regarded as mere accompaniments of its activities, but as guides and directing agencies intervening in the circle of its actions, and as facts, in the chain of physical causation. The sight of a stick may change the course of actions which a dog would otherwise have pursued—that is, the feeling of the moment, together with the faint recurrence of various past feelings and emotions therewith associated which the sight of the stick calls up, may cause such change. Besides its feelings, the general and the organic movements of the dog are, like our own, governed by a multitude of organic influences which are not felt, but which operate through the nervous system, and so must be taken as parallel with those which are felt, i.e. as unfelt, nervous psychoses. The animal then, like each of us, is a creature of activities partly physical, partly psychical, the latter—both the felt and the unfelt—being directive and controlling.

As we descend to the lowest animals, the evidence as to sentience fades. Yet from the resemblances of the lowest animals and plants, and from the similarity of the vegetative functions in all living creatures, we may, I think, analogically conclude that activities also take place in plants which are parallel with, and analogous to the unfelt psychoses of animals. As Asa Gray has said with respect to their movements: 'Although these are incited by physical agents (just as analogous kinds of movements are in animals), and cannot be the result of anything like volition, yet nearly all of them are inexplicable on mechanical principles. Some of them at least are spontaneous motions of the plant or organism itself, due to some inherent power which is merely put in action by light, attraction, or other external influences.'

I have already adverted to insectivorous plants, such as *Dionæa*. In such plants we have susceptibilities strangely like those of animals. An impression is made, and appropriate resulting actions ensue. Moreover, these actions do not take place without the occurrence of electrical changes similar to those which occur in muscular contraction. Hardly less noteworthy are the curious methods by which the roots of some plants seek moisture as if by instinct, or those by which the tendrils of certain climbers seek and find appropriate support, and having found it, cling to it by a pseudo-voluntary clasping, or, finally, those by which the little 'Mother-of-a-thousand' explores surfaces for appropriate hollows in which to deposit her progeny.

Nevertheless, nothing in the shape of vegetable nervous or muscular tissue has been detected, and as structure and function necessarily vary together, it is impossible to attribute sensations, sense-perceptions, instincts, or voluntary motions to plants, though the principle of individuation in each acts as in the unfelt psychoses of animals and harmonises its various life processes.

The conception then which commended itself to the clear and certainly unbiassed Greek intellect of more than 2,000 years ago, that there are three orders of internal organic forces, or principles of individuation, namely, the rational, the animal, and the vegetal,[1] appears to me to be justified by the light of the science of our own day.

[1] Difficult as it confessedly is to draw the dividing line between animals and plants, such difficulty is not inconsistent with the existence of a really profound difference between the two groups. That there should be a radical distinction of nature between two organisms, which distinction our senses, nevertheless more or less, fail to distinguish, is a fact which on any view must be admitted, since animals of very different natures may be indistinguishable by us in the germ, and in the earlier stages of their development. The truth of this is practically supported by the late Mr. Lewes, who says (as to the difference between the protoplasms from which animals and plants respectively arise): 'That critical differences must exist is proved by the divergence of the products. The vegetable cell is not the animal cell; and although both plants and animals have albumen, fibrine and caseine, the *derivatives* of these are unlike. Horny substance, connective tissue, nerve tissue, chitine, biliverdine . . . . and a variety of other products of evolution or of waste, never appear in plants; while the hydrocarbons abundant in plants are, with two or three exceptions,

I come now to the bearing of these remarks on the science of Biology generally.

Animals and plants may, as I have before said, be regarded either *statically*, by anatomy, or *dynamically*, by physiology.

Physiology, as usually understood, regards the properties of the ultimate morphological components of organisms, the powers of the various aggregations of such components, i.e. of the various 'tissues' and the functions of the different special aggregations and arrangements of tissues which constitute 'organs.'

But as each living creature is a highly complex unity—both a unity of body and also a unity of force, or a synthesis of activities—it seems to me that we require a distinct kind of physiology to be devoted to the investigation of such syntheses of activities as exist in each kind of living creature. I mean to say that just as we have a physiology devoted to the several activities of the several organs, which activities are the functions of those organs, so we need a physiology specially directed to the physiology of the living body considered as one whole, that is, to the power which is the function, so to speak, of that whole, and of which the whole body, in its totality, is the organ.

In a word, we need a *physiology of the individual*. This science, however, needs a distinct appellation. I think an adequate one is not far to seek.

Such a line of inquiry may be followed up, whatever view be accepted as to the nature of those forces or activities which living creatures exhibit. But if we recognise, as I myself think our reason calls on us to recognise, the existence in each living being of such a 'principle of individuation' as I have advocated the recognition of, then an inquiry into the total activity of any living being, considered as one whole, is tantamount to an inquiry into the nature of its principle of individuation. Such an inquiry becomes '*Psychology*' in the widest and in the original signification of that term—it is the Psychology of Aristotle.

Mr. Herbert Spencer has already made a great step towards reverting to this original use of the term, for he has made his 'Pyschology' conterminous with the animal kingdom, having made it a history of the psychoses of animals. But the activities of plants must not be ignored. A science which should include the impressionability and reactions of a Rhizopod, and exclude the far more striking impressionability and reactions of Venus's Fly-trap, and of other insectivorous plants, the recognised number of which is greatly on the increase, must be a very partial and incomplete science. If Psychology is to be extended (as I think Mr. Spencer is most rational in extending it) to the whole animal kingdom, it must be made to include the vegetable kingdom also. Psychology, thus understood, will be conterminous with the whole of Biology, and will embrace one aspect of organic dynamics, while physiology will embrace the other.

Physiology will be devoted (as it is now) to the study of the activities of tissues, of organs and of functions, *per se*, such, e.g., as the function of nutrition, as exhibited in all organism from the lowest plants to man, the functions of respiration, reproduction, irritability, sensation, locomotion, &c., similarly considered, as manifested in the whole series of organic forms in which such powers may show themselves.

Psychology will be devoted (according to its original conception) to the study of the activities of each living creature considered as one whole—to the form, modes, and conditions of nutrition and reproduction as they may coexist in any one plant; to these as they may coexist with sensibility and motility in any kind of animal, and finally to the coexistence of all these with rationality as in man, and to the interactions and conditions of action, of all these as existing in him, and here the science

absent from animals. Such facts imply differences in elementary composition; and this result is further enforced by the fact that when the two seem to resemble, they are still different. The plant protoplasms form various cells, but never form a cartilage cell, or a nerve cell; fibres, but never a fibre of elastic tissue; tubes, but never a nerve tube; vessels, but never a vessel with muscular coatings; solid "skeletons," but always from an organic substance (*cellulose*), not from phosphates and carbonates. In no one character can we say that the plant and the animal are identical; we can only point throughout the two kingdoms to a great similarity accompanying a radical diversity.'—(*The Physical Basis of Mind*, p. 129.)

which corresponds to the most narrow and restricted sense of the word, psychology, i.e. the subjective psychology of introspection, will find its place.

Psychology in the widest sense of the term, in its oldest and in what I believe will be its ultimate meaning, must necessarily be, as to its details, a science of the future. For just as physiology requires as a necessary, antecedent condition, a knowledge of anatomy—since we must know that organs *exist* before we investigate what they *do*—so psychology requires as a necessary, antecedent condition, an already advanced physiology. It requires it because we must be acquainted with the various functions, before we can study their synthesis and interactions.

When, however, this study has advanced, one most important result of that advance will be a knowledge, more or less complete, of the innate powers of organisms, and therefore of their laws of variation. By the acquisition of such knowledge we shall be placed in a position whence we may advance, with some prospects of success, to investigate the problem of the 'Origin of Species'—the biological problem of our century.

This reflection leads me back once more to my starting point, the merits of the great French naturalist of the last century, whose views as to variation, and as to animal psychosis, have enabled me to bring before you the questions on which I have presumed to enter. Buffon's claims on our esteem have, I think, been too much forgotten, and I rejoice in this opportunity of paying my debt of gratitude to him by recalling them to recollection. As to the questions which his words have suggested to me and upon which I have thus most imperfectly touched, the considerations I have ventured to offer may or may not commend themselves to your approval; but, at least, that they are the result of not a few years of study and reflection, and I am persuaded they have consequences directly or indirectly affecting the whole field of biological inquiry, which belief has alone induced me to make so large a call upon your patience and your indulgent kindness.

The following Paper and Reports were read:—

1. *On the Occurrence of Leptodora hyalina in England.*
By Sir John Lubbock, *Bart., V.P.R.S., M.P.*

Sir John called the attention of the Section to the occurrence in England of Leptodora hyalina, a very interesting crustacean first found in deep lakes abroad, and more recently in a reservoir near Birmingham. It was forwarded to him by Mr. Bolton. Like many marine organisations it was as transparent as glass. This rendered the creature less conspicuous to its foes. Like other animals of the same group it laid two kinds of eggs. The young produced from these two kinds of eggs were said to differ from one another, but this he had had no opportunity of verifying. He then entered into a description of the little animal, and by means of sketches illustrated the peculiar functions of the different organs, pointing out the difference of the organs in male and female.

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2. *Report of the 'Close Time' Committee.*—See Reports, p. 165.

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3. *Report of the Committee appointed for the purpose of exploring the Marine Zoology of South Devon.*—See Reports, p. 165.

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4. *Report on the progress of the Zoological Record.*

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5. *Report of the Committee on the Zoological Station at Naples.*—See Reports, p. 165.

6. *Report of the Committee for investigating the Natural History of Socotra.*—See Reports, p. 210.

FRIDAY, AUGUST 22.

The following Papers were read:—

1. *On Fruits and Seeds.*
By Sir JOHN LUBBOCK, *Bart., V.P.R.S., M.P., D.C.L., LL.D.*

Sir John commenced by calling attention to the difference presented by seeds, some being large, some small, some covered with hooks, some provided with hairs, some smooth, some sticky, &c., and after observing that there were reasons for all these peculiarities, proceeded to attempt to explain some of the more striking. In the first place, he said, many seeds required protection from birds and insects. Hence the shells or husks of the beech, Spanish chestnut, horse chestnut, walnut, &c. In some cases, as in the common Herb Robert, the calyx or outer envelope of the flower opens when the flower expands, closes over the seeds when the flower fades, and opens again when the seeds are ripe. In other cases the flower-stalk changes its position. Thus, in the Dandelion, it is upright when the flower is expanded, lies close to the ground after the flower has faded, and rises again when the seeds are ripe. In the Cyclamen, again, the flower-stalk curls itself up into a spiral after the flower has faded,

He then called attention to the modes of dispersion, by means of which seeds secure a sort of natural rotation of crops, and are also in other cases enabled to rectify their frontiers. Some plants actually throw their seeds. Thus, in the common Cardamine, the outer membrane of the pod becomes very tense, and when ripe, at the least touch it gives way at the base, and curling up with a spring, throws the seeds three or four feet. The common geraniums and violets also throw their seeds, and so do some of the cucumbers; but in these cases the mechanism is different. He then described the curious 'elaters' of the equisetums, and other means of dispersion possessed by seaweeds and other low organised plants. Among the higher plants the seeds are in many cases transported by the wind. Sometimes, indeed, the whole plant is thus blown about, as in the case of the celebrated Rose of Jericho, an annual, inhabiting the sandy plains of Palestine, Syria, and Arabia, which, when dry, curls itself up into a ball, and is thus blown over the surface of the ground till it comes to a damp place, when it uncurls, the pods open and shed their seed.

Many seeds are provided with a wing which catches the wind and thus aids in dispersion. Such seeds occur, especially on trees, such as the pine, fir, ash, maple, sycamore, hornbeam, and many exotic species. In these cases the seeds are large, but many herbs have small seeds, provided with foliaceous expansions serving the same purpose. These are sometimes so thin as to be transparent, and in *Thysanocarpus elegans* the membrane is even perforated by a series of holes. In other cases the seeds are provided with hairs, which catch the wind, sometimes forming exquisite fairy parachutes. Such, for instance, are the dandelion, &c.; but it is curious that very different parts of the plant are modified into these hairs. Thus in the dandelion and valerian it is the calyx; in the bulrush, the perianth, in the willow herb, the crown of the seed; in cotton grass, the base. In the true cotton the whole seed is covered with hairs. Thus, then, although the result is the same, the mode of arriving at it is very different.

He then proceeded to the cases in which the dispersion of seeds is effected by the agency of animals. In many cases the seed is surrounded by a sweet, fleshy pulp, which is eaten, while the true seeds, being surrounded by a tough

shell, remain undigested. Such fruits are generally brightly coloured, such as the strawberry, peach, apple, currant, &c.; the colours, like those of flowers, serving to attract animals. In other cases the action of animals is involuntary. These may be divided into two classes, those in which the seeds adhere to animals by hooks, and those in which this is effected by sticky glands. Various cases of both were cited, and specimens shown, especially the South African Harpagophyton, a plant whose seeds are provided with terrible hooks, more than an inch long. These seeds are said sometimes even to destroy lions; they roll about over the sandy plain, and if one attaches itself to the skin the wretched animal tries to tear it off, and getting it into its mouth, perishes miserably. Sticky seeds are also thus transported.

The next point is that seeds should find themselves in a spot suitable for growth. Most seeds, we know, germinate on the ground: the mistletoe, however, is parasitic on trees, and its seeds are imbedded in a viscid substance, so that if dropped by a bird on a bough it adheres to it, and is in no danger of being blown or washed off. An allied species described by Sir J. Hooker, which lives on the beeches of Tierra del Fuego, has four long feathery, flexible appendages. By means of them it is blown from tree to tree, and as soon as the seed touches a twig the appendages twine round it and thus anchor the seed.

In some cases plants bury their own seed. This, for instance, is the case with our subterranean clover, and the ground-nut of the West Indies. In both cases the seed-stalk elongates, curves downwards, and forces the seed into the ground. In other instances the seed buries itself, as in some grasses and the Crane's Bills (*Erodium*). The seed of Stipa, for instance, is pointed, and clothed with short, reversed hairs. It terminates in a spiral appendage, covered with similar hairs. Now, if one of these seeds is laid on the ground, it remains quiet as long as it is dry, but as soon as it is damp the hairs on the seed commence to move outwards, gradually raising the seed into an upright position, with its point downwards. The spiral appendage then begins to unwind, and if its hairs come in contact with any obstacle, such as a leaf, twig, &c., as is most probable, the seed is then forced into the ground. Sir John, in conclusion, called attention to mimicking seeds. The pods of Scorpiurus, for instance, a plant allied to the vetch, do not open, but they look so exactly like worms that birds are probably induced to peck at them and thus free the seeds.

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2. *On the Insects which Injure Books.* *By* Professor Westwood, *M.A.*

Referring to an address delivered by Dr. Hagen, of Harvard College, Mass., U.S., on July 2, 1879, before the American Library Association on the same subject, Professor Westwood passed in review the life-history of the different species of insects which have been found to destroy books and printed papers, several of which were not noticed by Dr. Hagen in his address.

The caterpillars of the moth *Aglossa pinguinalis*, and also of a species of *Depressaria*, often injure books by spinning their webs between the volumes, gnawing small portions of the paper with which to form their cocoons. A small mite (*Cheyletus eruditus*) is also found occasionally in books kept in damp situations, where it gnaws the paper.

A very minute beetle (*Hypothenemus eruditus*, Westw.) forms its tiny burrows within the binding of books, of which a small portion, with specimens of the beetles, was exhibited.

The small silvery insect (*Lepisma saccharina*) found in closets and cupboards where provisions are kept, also feeds on paper, of which a curious example was exhibited in a framed and glazed print, of which the plain portion was eaten, whilst the parts covered by the printing-ink were untouched. The Professor had been assured that the same fact had been observed in India, where some of the Government records had been injured in the same manner. This habit of the Lepismæ had not been previously recorded.

The white ants (*Termitidæ*) are a constant source of annoyance in hot and

warm climates, eating all kinds of objects of vegetable origin, of which several instances were recorded by Dr. Hagen, including the destruction of a stock of Bibles and prayer-books, and the professor exhibited a small Bible which had been greatly gnawed by these insects. Cockroaches (*Blatta orientalis*) are also equally destructive to books when they fall in their way, of which some sad instances were recorded by Dr. Hagen.

But it is the *Death-watches* (*Anobium pertinax* and *striatum*) which do the greatest injury, gnawing and burrowing not only in and through the bindings, but also entirely through the volume, and instances have been recorded where not fewer than twenty-seven folio volumes placed together on a book-shelf had been so cleanly drilled through by the larva of this beetle that a string might be run through the hole made by it and the volumes raised by the string.

Various remedies for the destruction of these insects were mentioned, and especial notice was directed to a 'Report of the Commission appointed to inquire into the causes of the decay of wood carvings (by the Anobia), and the means of preventing and remedying the effects of such decay,' issued by the Science and Art Department of the Committee of Council on Education at South Kensington in 1864, in which Report the Professor gave an account of the life-history of the Anobia.

Reference was also made to a previous Parliamentary Report on the National Gallery, with the observations thereon by the late Dr. Waagen, especially with reference to the state of Sebastian del Piombo's picture of the Raising of Lazarus, which had been attacked by the Anobia. The Arabic MSS. in the Cambridge Library, brought from Cairo by Burckhardt, and various Oriental MSS. in the Bodleian Library, had been much injured by these insects.

The remedies against the attacks of the Anobium upon objects of carved wood must necessarily be of a different character from those used against the book-worms, which are the larvæ of the Anobia. In the former case, *saturation* with chloride of mercury dissolved in methylated spirits of wine or other analogous fluid had been found to be efficient, but with respect to books it was necessary to have recourse to *vaporisation*, and experiments were recorded in which objects attacked by the Anobia had been placed in a large glass-case made as air-tight as possible, and small saucers with pieces of sponge saturated with carbolic acid were placed at the bottom of the case, and on the recommendation of the Professor it had been found successful to place the infected volumes in the Bodleian Library in a closed box with a quantity of benzine in a saucer at the bottom. A strong infusion of colocynth and quassia, chloroform, spirits of turpentine, expressed juice of green walnuts, and pyroligneous acid have also been employed successfully. Fumigation on a large scale may also be adopted by having a room made as air-tight as possible, burning brimstone in it, or filling the room with fumes of prussic acid or benzine.

Lastly, Dr. Hagen suggested that by placing an infected volume under the bell-glass of an air-pump and extracting the air, the larvæ would be found to be killed after an hour's exhaustion.

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3. *A Case of Disputed Identity, Haliphysema.*
By Professor Ray Lankester, *F.R.S.*

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4. *On Budding in the Syllidian Annelids, chiefly with reference to a branched form procured by H.M.S. 'Challenger.' By* W. C. McIntosh.

Propagation by budding is a prevalent feature amongst the Cœlenterata, the organisms assuming in many cases a dendritic appearance, so that the name of sea trees given to them by our fishermen is by no means inappropriate to their external contour. A similar condition is seen in many of the Polyzoa, and in the creeping stolons of *Clavelina* and *Perophora*. In the sub-kingdom Vermes, again, naturalists have long been familiar with a mode that has been called propagation by division

or Fissiparous development. Thus O. F. Müller describes two kinds of budding in the freshwater *Nais proboscidea*, and gives an account of the same process in *Nereis prolifera* (the *Autolytus prolifera* of modern authors). Amongst others, De Quatrefages and Frey and Leuckart in the same species, Milne Edwards in *Myrianida*, Sars and Huxley in *Filigrana*, O. Schmidt in *Nais*, *Microstoma*, and *Filigrana*, Max Schultze, R. Leuckart, and Tauber in the former species, Alex. Agassiz in *Autolytus cornutus*, Schmarda in *Catenula*, and Lankester in *Chætogaster*, show how widely this mode of development has been recognised. The feature that mainly concerns us at present in regard to these descriptions is the fact that a new animal is produced, in a line with the old, by various modifications of budding. In no instance is there any approach to a branched condition by lateral offshoots from either parent-stock or bud. As an example of one of the best-known marine forms the account of *Autolytus cornutus* by Alex. Agassiz may be cited. This species exhibits a kind of alternation of generation, the parent-stock (which is a sexual) giving rise posteriorly to male and female buds, which differ much in appearance from each other. The latter produce ova, which by and by develop, in the peculiar body sac, into a swarm of parent-stocks with which the cycle commenced.

The discovery of a species (*Syllis ramosa*) of the same family (*Syllidæ*) which forms an intricate series of branches by lateral budding of the parent-stock, by Sir Wyville Thomson in a Hexactinellid sponge from Zebu, is one of the remarkable additions to our knowledge made by the voyage of H.M.S. 'Challenger.'

The Syllidian[1] is located for the most part in the basal canals of the sponge, above the 'wisp.' In this region masses of the annelid about a quarter of an inch in diameter occur, and a multitude of branches pass into the smaller canals adjoining. Two of such masses are especially conspicuous. The intricate manner in which the branches are arranged makes it a very difficult matter to dissect them out, especially when the friability of the annelid and the sharp spicules of the sponge are taken into account. Even after removal from the sponge it is a laborious operation to unravel them without frequent rupture.

The masses and their numerous branches, as well as the isolated portions, consist of a *Syllis*-like annelid of the thickness of common sewing-thread. No head can be observed either in the parent-stock amongst the masses or in the canals elsewhere, so that they must either be very few, only occasionally developed, or by some means have been swept off, as it is hard to believe that they are entirely absent. The latter, however, must be the condition in some of the examples (unless we are to suppose that all are connected with a single head), which, therefore, would appear to derive nourishment at the open end, yet in many the aperture rapidly develops a bud which nearly closes it. If in life there are many examples with such open ends, then the whole series branching from them presents an analogous condition to that of very elementary animals, the food being swept in with the sea-water to traverse the moniliform nutritive canal throughout the organism.

The body of the animal stretches, from any of the broken ends, of a nearly uniform diameter for a considerable distance, the numerous narrow segments being distinctly marked, and each furnished laterally with well-formed feet. The latter have dorsally a long and often gracefully curved cirrus, composed of a variable number of segments, since injury and reparation constantly occur; moreover the cirri are alternately long and short. The longer cirri have about twenty-six segments, and all the organs are gently tapered from base to apex. Beneath and confluent with the base of the cirrus is the somewhat conical setigerous region, which has a few simple bristles, with a stout and slightly curved shaft, the dilated distal portion having the simple terminal process apparently anchylosed to it. This modification of the bristle is peculiar. A single stout spine supports the setigerous region, and, as usual, its point passes to the upper border. The ventral cirrus is broad and short, its tip being within the vertical line of the former division.

The body of the annelid appears to have a furor for budding—laterally, terminally, and wherever a broken surface occurs. The young buds remain slender till they have reached a considerable length, and into each a diverticulum of the alimentary canal of the parent enters. These buds, on attaining a certain size, by

[1] See forthcoming *Proceedings of the Linnæan Society*, 'Zoology.'

and by give off other buds, so that the whole has a remarkably branched condition. The tail of the bud (i.e. its distal point) is early formed, and soon becomes furnished with two long cirri. Indeed, it would seem that in such a case the tail and the anus were more useful than the head, the eyes, and the finished buccal and pharyngeal apparatus.

The number of buds seems to be indefinite, the data at present being insufficient to enable me to fix a limit. Some of the larger fragments show nine or ten buds, yet they are evidently far from being complete. The absence of a head leaves great uncertainty on the latter point, and, if it existed at all, it could only have been in the siliceous stem of the sponge, which had been torn off.

Two female buds were found. One of these was still attached by its pedicle of four segments to the parent-stock. These intermediate segments somewhat resembled those of ordinary buds, only they were more slender. All had rudimentary lateral cirri and setigerous processes. The diverticulum of the alimentary canal proceeded from the main trunk in the ordinary way, passed through the anterior segments of the bud, and became lost in the opacity caused by the ova. The head of the bud is bilobate, and furnished dorsally with a large reddish-brown eye on each side, and a still larger pair, of similar shape (somewhat circular) and colour, on the ventral surface. These eyes, while useful for both dorsal and ventral vision, approach so near the margins that they are also available for lateral sight. The head terminates laterally in two short cirri and a setigerous process furnished with a spine.

The body of the female bud is somewhat fusiform, gradually increasing in diameter till full breadth is attained, and, after a nearly cylindrical region, diminishing towards the tail, though to a less degree than anteriorly. The entire body, from the middle of the second segment backwards, as well as the bases of the feet, is filled with ova, which in each case shows germinal vesicle and spot. The anterior segments are provided with bristles of the same type as the parent-stock, only the terminal appendage is more differentiated. None of the long simple bristles are apparent in this fragmentary example.

Exactly opposite the point from which the pedicle of the foregoing bud sprang is another small bud, consisting of upwards of a dozen segments. Moreover, in the same specimen a pair of young buds occur opposite each other. In these cases the segment of the intestine of the parent-stock, from which the diverticulum proceeds, is shorter than the rest. It would seem that the bud arises opposite a foot, and there is no evidence that a bud ever arises between two (successive) feet. The shortening of the intestinal segment may be due to the appropriation of the substance of both it and the body-wall in the production of the new bud.

A free female bud, again, occurred in one of the basal canals of the sponge. It closely agrees with the description of the foregoing specimen, except in the larger garnet-tinted eyes, and the presence of beautiful tufts of long simple bristles in each foot. Its length is about 9 mm., and its breadth, including the latter, is rather more than 2 mm. There are twenty-nine segments; but the condition of the tail is open to doubt. Dorsally each segment has a slender and distinctly-jointed cirrus. Beneath the foregoing is a dense tuft of long translucent simple bristles, with broad flattened tips, after the fashion of the straight Roman swords, but marked at the tip by two peculiar longitudinal processes, and sometimes the end assumes a fimbriated appearance. The setigerous region beneath is short and conical, having superiorly the spine and inferiorly the bristles, which differ from those of the parent-stock, in showing a more evident differentiation at the junction of the terminal process. Ventrally is a tongue-shaped cirrus, which nearly reaches the tip of the setigerous region. The entire body is filled with ova, which likewise occupy the feet, almost to their tips; the first segment and the extremity of the tail (which is apparently in process of regeneration) alone being devoid of them. Some of the feet, indeed, assume a bulk four or five times larger than the others, from distention with ova. The latter, apparently, have embryos internally.

Amongst the tangled masses in the channels of the sponge was a fragment of the posterior end of a form which differed from either of the foregoing. The feet, which are well-marked and long, have dorsally a slightly convex margin; ventrally the outline is also somewhat convex at the base, but curves upward toward the

tip. A short cirrus of four or five segments extends from the extremity of the dorsal margin, while beneath it is a dense tuft of long straight sword-shaped translucent bristles, similar to those described in the female bud. A flat papilla, about the middle of the bristle-bundle, shows that part of the foot to which the tip of the slender supporting spine proceeds. This slender spine diverges upward from the side of the stronger inferior one, the arrangement of the parts indicating that the foregoing tuft of simple bristles is of less morphological value than the others. A somewhat lanceolate process occurs at the ventral margin of the foot, and apparently corresponds to the setigerous division. It is supported by the stronger spine, and bears two or three bristles, with simple terminal processes, similar to those in the parent-stock. No ventral cirrus is present. The body contains a large number of granules, and also masses of what appear to have been fully-formed spermatozoa. Whether this is the male of the above form or another is, of course, an open question; but the bristles certainly correspond.

SATURDAY, AUGUST 23.

The Department did not meet.

MONDAY, AUGUST 25.

The following Papers were read:—

1. *Recent Additions to the Moss-Flora of the West Riding.* *By* CHARLES P. HOBKIRK, *F.L.S.*

This paper is supplementary to one read by the author at the Bradford Meeting in 1873, 'On the Mosses of the West Riding,' giving a list of 294 species, with their localities. After treating on the work of the Yorkshire Naturalists' Union, in investigating the fauna and flora of the county, the author particularised some of the chief species found since 1873, and gave the history of them, viz., *Seligeria tristicha* at Littondale; *Aulacomnium turgidum* at Whernside; *Fontinalis gracilis* at Malham Cove; *Plagiothecium nitidulum* at Penyghent, &c. Four lists were appended to the paper, viz., (1) New species, 48; (2) Species found in fresh localities, 142; (3) Localities previously known, but not recorded, 29; and (4) Species inserted in error in previous list, 8: making the total number of species now recorded for the Riding, 327.

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2. *On the Embryology of Gymnadina conopsea.* *By* H. MARSHALL WARD.

The ovule arises on the placenta as a mass of cells consisting of an axial row, surrounded by an epidermal layer of cells one deep: the terminal cell of the axial row, just beneath the epidermal layer, enlarges and cuts off two cells at its apex as described by Strasburgher; these cap-cells and the epidermal cells become flattened and finally destroyed as the cell which remains enlarges and becomes the embryo sac. The existence of the remains of the cap-cells as refractive masses above the embryo sac is cited as evidence against Vesque's view as to the origin of the embryo sac by the fusion of two or more superposed cells. The protoplasm in the embryo sac then divides into two masses, one passing to each end of the sac; they there undergo further division into fours. Of the four nucleated masses

in the anterior part, one becomes the egg-cell, attached to two others, which have elongated as the 'Gehülfinnen' or 'Synergidæ' of Strasburgher, and become packed into the top of the sac; the fourth remains suspended in the protoplasm of the sac, and is said by Strasburgher to fuse with one of the similarly produced masses below, the product becoming the nucleus of the embryo sac. The three remaining nuclei are the 'antipodal cells' of authors. The writer confirms these views, except that the actual blending of the two nuclei has not been seen; in Ranunculus, Anthericum, and other plants, however, the evidence is sufficient to render this view most likely, since two nuclei in all stages of approach occur, as well as sacs with one large central nucleus.

The fertilised ovum divides by a horizontal wall into two similar cells; the upper one becomes the suspensor, and divided by cross-walls only; the lower is cut by walls in alternating planes at right angles to one another into a few-celled simple embryo, showing no differentiations into tissues, or into cotyledons, stem, root, &c. Short reference was made to the proposed homologies for these structures in the embryo sac, and especially to the reasons against accepting the older views as to the correspondence between the synergidæ and the canal-cells of the archegonium.

Confirmatory results have also been obtained in Butomus, Ranunculus, Alisma, Anthericum, and others. The views of Vesque do not appear to be supported by these researches; and those of Warming appear to involve considerable difficulties as to the meaning of the embryo sac nucleus.

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3. *On the Homologies of the Cephalopoda.* *By* J. F. Blake.

The flexure of the intestine in Cephalopoda and Pteropoda is 'pedal,' and that of other Odontophora, 'cephalic;' and the body of a cephalopod must be placed with the mantle cavity horizontal for comparison with a gastropod. The arms are not homologous with the foot, but form an 'antivelum.' The labial and tentacular processes, and not the individual tentacles of a Nautilus are shown to be homologous to the arms of an Octopod. The hood is associated with the aptychus of the Ammonite, the shell of an Argonaut, and the neckplates of a Sepia. The Ascoceras is cited to show the relations of the Sepia-bone to the Nautilus shell.

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4. *On Cyclops.* *By* Marcus M. Hartog, *M.A.*, *B.Sc.*

The nervous-cord of Cyclops is essentially Copepodan in type, it is not distinctly dilated into special ganglia containing cells evenly distributed up to the third thoracic segment, which is here continued by a fibrous commissure to a ganglion in the next segment. Beyond this are no cellular elements in the cord, which bifurcates in the second abdominal segment, and the branches terminate in the furca. The sensory and motor nerves appear to be wholly distinct, the latter coming off at a higher or deeper level. All the sensory nerve-fibres pass through a bipolar ganglion cell near their distal termination. Minute rounded spaces in the hypoderm, especially one at the base of the last thoracic limb, and a pair on either side of the upper face of the front of the head, appear to be auditory organs (containing one or more minute, irregular, highly-refractive corpuscles in the male). Respiration in Cyclops is entirely anal.

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5. *On Mimusopeæ, a Section of the Order Sapotaceæ.* *By* Marcus M. Hartog, *M.A.*, *B.Sc.*

In this paper the genus Dipholis is merged in Bumelia, and the genera Imbricaria, Labramia, and Muriea in Mimusops: a review of the differential characters hitherto relied on showing their inadequacy from every point of view—even convenience.

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6. *On Solid-mounted Preparations.* *By* L. C. Miall.

TUESDAY, AUGUST 26.

The following Papers were read:—

1. *On a Spore-producing Glœocapsa, from the great Conservatory at Chatsworth.* *By* Professor M. A. Lawson.

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2. *On the Capreolus (of Lister) or the Spermatophore of some of the Indian species of the Helicidæ.* *By* Col. H. H. Godwin-Austen, *F.Z.S.*

The author points out the importance of making an examination of the animal in many genera of the Helicidæ, and thus obtaining better characters for specific distinction than are often presented by the shell alone. The organ first discovered and described by Lister in 1694 is treated of, and the views of later naturalists alluded to. Many different forms of the Spermatophore found in Helices from Eastern Asia are shown, and the position of the organ in the generative system of *Helicarion magnifica* from Burmah is described.

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3. *On a Sponge from the Norwegian Coast, simulating a Hydroid Polyp.* *By* W. J. Sollas, *M.A.*

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4. *Comparison of the Effects of the Frosts of* 1860-1 *and of* 1878–9. *By* E. J. Lowe, *F.R.S.*

The greatest cold of 1860 exceeded that of last winter by 10°; it was 6° below zero in 1860, it was 4° above zero in the last frost, i.e., 4 feet above ground.

The present paper records the great difference in the effects in the two frosts at Highfield House.

	Frost of 1860	Frost of 1878
Elm (broad-leaved)	Uninjured	Three-fourths of the boughs killed back at least 2 feet
Acacia (long-spined)	Slightly injured	Many boughs killed, and was a month later in coming into leaf
Bay (sweet)	Killed to the ground	The ends of the shoots only killed, and all the leaves
Cedar (deodar)	Became deciduous; otherwise uninjured	Not injured
The arbutus	Killed to the ground	Half the branches killed, the others injured
Aucuba	"	Uninjured
Pampas grass	Killed	Killed
Araucaria imbricata	Killed to where buried in snow	Uninjured
Yew	Slightly damaged	Slightly damaged
Wellingtonia gigantea	Much injured	Slightly injured
Evergreen oak	Many killed; all became deciduous	Uninjured
Ivy	More or less injured	More or less injured
Fennel	Uninjured	All killed
Sage	Killed	Uninjured
Roses, standards	All killed	Many killed, nearly all injured

	Frost of 1860	Frost of 1878
Roses on their own roots	Many killed	Uninjured
Retinospora obtusa . .	Killed	,,
,, squamosa .	,,	Slightly injured
,, leptoclada .	—	Uninjured
,, ericoides . .	—	,,
,, filifera . .	—	,,
,, plumosa . .	—	,,
,, ,, argentea	—	Slightly injured
Juniperus excelsa . . .	Killed on the north half of the tree	Uninjured
,, chinensis aurea	—	,,
Phormium tenax . . .	Killed	Only killed to the ground
Eugenia Ugni	,,	Half the branches killed
Yucca gloriosa	,,	Slightly injured
Cineraria maritima . .	,,	Killed
Laurel, common . . .	Many killed to ground	Uninjured
,, Portugal . . .	Nearly all killed	,,
Holly	Most killed in the branches to the height of 7 feet	,,
Thuja aurea	Mostly killed	Slightly injured
Cork tree	Killed	—
Deutzia gracilis . . .	Severely injured	Uninjured
Quince	Killed	—
Yew, golden	Slightly injured	Uninjured
Pinus insignis	Killed	,,
Abies pygmea	Slightly injured	,,
,, Menziesii	Became deciduous, and had no leaves for a year	,,
,, morinda	Slightly injured	,,
Laurustinus	All killed	,,
Picea Nordmanniana . .	Uninjured	Lost half its leaves and some boughs
Walnut	Boughs killed and one tree	Uninjured excepting a want of vigour, leaves only half the usual size
Apples	—	Leaves small and fruit scarce and remarkably small
Garrya elliptica . . .	Killed	Only blooms killed
Double gorse	Many killed	Slightly injured
Hydrangea hortensis .	Killed to ground	Killed back several inches
Pæonia moutan . . .	Killed to ground	Uninjured
Berberis Bealii	Many killed	,,
Weigelia rosea	Killed	,,

The above will sufficiently illustrate the effects of the frosts in two severe winters.

It is worthy of remark that instead of the cold killing the slugs and various pests of plants, they were never known so numerous. Many hardy plants, *in pots*, were killed, such as Ivy, Pteris aquilina, &c., when they escaped if plunged in the ground.

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5. *The rarer Birds occurring in South and West Yorkshire.* *By* T. Lister.

DEPARTMENT OF ANTHROPOLOGY.

CHAIRMAN OF THE DEPARTMENT.—E. B. Tylor, Esq., D.C.L., F.R.S.
(Vice-President of the Section.)

[For Mr Tylor's Address see p. 381.]

THURSDAY, AUGUST 21.

The following Papers were read :—

1. *On the Cagots.* *By* D. HACK TUKE, *M.D., F.R.C.P.*

1. The Cagots are not the descendants of the Goths; they are not a distinct race, but a despised class among the people of the country in which they live.
2. They are not more subject to goître or to cretinism than the inhabitants in their vicinity; in short, cagotism and cretinism are in no way allied.
3. The present representatives of the Cagots are now recognised by tradition, and not by their features, and are not distinguished by any peculiar mental or physical disorder, except when residing in an unhealthy locality.
4. Although nothing like leprosy or leucoderma has for long affected the Cagots, and no one on the spot regards them in this light, there is evidence to show that they were originally either lepers labouring under a particular variety of leprosy, or were affected with leucoderma; the form of the affection accounting for their being regarded as in some respects different from ordinary lepers, though shunned in the same way.
5. Many were no doubt falsely suspected of leprosy in consequence of some slight skin affection. Others again, in later centuries, were members of families in whom the disease had died out.

2. *Evidence of the Existence of Palæolithic Man during the Glacial Period in East Anglia.* *By* SYDNEY B. J. SKERTCHLY, *F.G.S., H.M. Geological Survey.*

The object of this paper is chiefly to record the sections in which the author has discovered palæolithic implements beneath the chalky boulder clay in East Anglia.

The beds which yield the implements are a series of loams, clays, and sands, to which the author has given the name of Brandon Beds. They occur at the top of the Middle Glacial Series of Messrs. S. V. Wood, jun., and F. W. Harmer, and underlie the Chalky Boulder Clay or Upper Glacial of the above-named authors.

They have yielded palæolithic implements in many places, but only those will be described in which the Chalky Boulder Clay overlies the Brandon Beds at the present time.

Mildenhall.—Near Mildenhall, on the River Lark, in Suffolk, two sections have yielded implements. They are at Warren Hill and Mildenhall Brickyard.

The section at Warren Hill is as follows :—

	ft.	in.
1. Sandy soil, &c.	2	0
2. Chalky Boulder clay	6	0
3. Gravel	4	0
4. Loamy clay	4	0
6. Boulder clay	6	0
6. Chalk	0	0

This spot has yielded great numbers of flakes and many implements. It was originally described by Professor Prestwich, but the boulder clay has only recently been exposed above the tool-bearing loams.

At Mildenhall Brickyard the section is—

	ft.	in.
1. Sandy soil	1	0
2. Chalky Boulder clay	6	0
3. Loam	10	0
4. Chalk	0	0

From this place many implements and flakes have been obtained. They occur in the loam.

Culford, in Suffolk.—The Brandon Beds are here dug under 15 feet of solid boulder clay. From these I obtained two flakes.

West Stow in Suffolk.—Boulder clay overlies, underlies, and wraps round the Brandon Beds at this place. Some well-worked implements have been obtained, one of which was dug out by the author.

Brandon.—Near Brandon the same beds are being dug beneath boulder clay, and have yielded very good implements.

The peculiarities of the implements are pointed out, and the mode of distinguishing them from specimens from the gravels is indicated.

The author in this paper merely desires to emphasize the fact that from several sections he has himself dug out palæolithic implements from below tough, undisturbed chalky boulder clay.

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3. *On a New Estimate of the Date of the Neolithic Age.*

By SYDNEY B. J. SKERTCHLY, *F.G.S., H.M. Geological Survey.*

M. Morlot estimated from the rate at which the cone of Tinière was forming, that from 5,000 to 7,000 years ago Switzerland was in its Neolithic age; and M. Gillierson ascribes a like date to that period from a calculation of the rate of silting up of a portion of the Lake of Bienne.

The author points out that a similar result is obtained from physical evidence in the Fenland. This district occupies an area of 1,300 square miles around the great bay of the Wash. The surface of the inland portions consists of peat, and that of the seaward parts of marine silt. This silt is still in process of deposition, and the land is consequently gaining upon the sea. From the time of the Roman occupation, at least, banks have been successively erected to reclaim the newly formed ground; and as the dates of these banks are known, very accurate estimates can be formed of the rate at which the deposition is going on in different parts. The maximum rate is 59 feet per annum; and 4 miles of new land has been formed since the oldest banks were erected. These banks are generally ascribed to the Romans; but they are probably British. In this estimate they will be taken as Roman, in order that the age may not be over-estimated, and the maximum rate of deposition will also be used as giving the minimum of time.

The geological evidence shows that as the silting went on, and the area became converted into land, peat grew and gradually spread over the newly formed ground. But in process of time the climate became unfitted for the growth of peat, which gradually lost its vigour, and finally ceased to form. Hence a wide stretch of silt land borders the Wash, upon the surface of which no peat has ever formed. The peat died upon its eastward march; the silt still travels on.

The nearest approach of the peat to the banks along the line of most rapid accumulation is 12 miles distant therefrom. The age of this, the newest peat in the Fenland, can be thus determined. Between the 'Roman' banks and the sea lie four miles of silt, which has taken 1,700 years to accumulate. Between these banks and the sea lie 12 miles of silt, which at the same rate of formation would take 5,100 years to accumulate. Adding 5,100 to 1,700 years, we have 6,800 years as the least possible age of the newest peat. This peat has yielded many Neolithic implements. Hence we may assume that 7,000 years will take us back

into the Neolithic age. The coincidence of this estimate with the two Swiss ones above mentioned is remarkable.

These results do not, however, give us the date of the introduction of the Neoliths into Europe, for neither in the Swiss nor English localities are we sure that the Neolithic relics belong to the early part of the Neolithic age. The author, indeed, has recently obtained evidence of Neolithic handiwork in Fenland peat of far greater age than that described, the peat bed underlying silt more than 7,000 years old. He is inclined to think that the Neolithic Age in England began at least 10,000 years ago, and perhaps 20,000 years; but that it does not approach the close of the Glacial epoch, seems to be shown by the fact that the older Fenland beds (themselves post-glacial) do not contain human relics.

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4. *A Classification of the Physical Conditions of Life.* *By* C. Roberts, *F.R.C.S.*

It is only by examining the physical condition of a large number of individuals by anthropometry that the actual state of health of a nation can be determined. The present paper indicates the direction in which investigation may be made by classifying the conditions of life which modify the development of the human body. The most important of the agencies are race, climate, nurture, occupation, and disease. An elaborate table accompanied the paper.

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5. *On the Yarra and the Languages of Australia in connection with those of the Mozambique and Portuguese Africa.* *By* Hyde Clarke, *V.P.A.I.*

In this paper Mr. Clarke showed that the Yarra dialect of Melbourne, and many others of North, East, South, and West Australia are to be identified with the Mozambique languages on the east coast of Africa, the Muntu, Kirimau, Marawi, &c., with those of the other Bantu or Kaffre languages of Portuguese South Africa. This was accompanied by a large table of words. Further, he showed that those Mozambique roots which are not represented in the Yarra, &c., are represented in the Echuca and other Australian languages, thus completing the chain of identity. Mr. Clarke pointed out that Dr. Caldwell had recognised the grammatical resemblances between Australian and the Dravidian of India, and Dr. W. H. Bleek between Australian and Bantu. They had not been able to follow up these resemblances or to account for them. He stated, in the facts in another paper, that these languages belonged to a common group, but had undergone different processes of development. He supported the view of Mr. Brough Smith that Australia had been under the influence of a white race in ancient epochs. Apart from the evidence of language, grammar, and mythology, he dwelt on the curious fact that the names of the languages of Australia are negatives, one of these negatives, *Kabi*, being common throughout the world. He also referred to the geographical doctrine of the Four Worlds, as taught in the School of Pergamus, in proof that Australasia had in earlier epochs been known to the ancients.

FRIDAY, AUGUST 22.

The Chairman delivered the following Address:—

In surveying modern scientific opinion, the student is often reminded of a doctrine proclaimed in the ancient hymns of the Zend-Avesta, that of *Zrvâna akarana*, or 'endless time.' Our modern schemes of astronomy, geology, biology are all

framed on the assumption of past time immense in length. In fact, one reason why the latter sciences grew so slowly till almost our own day, was their being shackled by the bonds of a short chronology, allowing no room for the long successive periods through which it is now clear that the earth with its plants and animals passed into their present state. Even the Science of Man, though concerned with the later forms of being, belonging to times which geologists treat as almost modern, has nevertheless to deal with periods of time extending far back beyond the range of history and chronology.

Looking back 4,000 to 5,000 years, what is the appearance of mankind as disclosed to us by the Egyptian monuments and inscriptions? Several of the best-marked races of man were already in existence, including the brown Egyptian himself, the dark-white Semitic man of Assyria or Palestine, the Central African of two varieties, which travellers still find as distinct as ever, namely, the black or Negro proper, and the copper-coloured negroid, like the Bongo or Nyam-nyam of our own time. Indeed, the evidence accessible as to ancient races of man goes to prove that the causes which brought about their differences in types of skull, hair, skin, and constitution, did their chief work in times before history began. Since then the races which had become adapted to their geographical regions may have, on the whole, undergone little change while remaining there, but some alterations are traced as due to migration into new climates. Even these are difficult to follow, masked as they are by the more striking changes produced by intermarriage of races. Now the view that the races of man are to be accounted for as varied descendants of one original stock is zoologically probable from the close resemblance of all men in body and mind, and the freedom with which races intercross. If it was so, then the fact of the different races already existing early in the historical period compels the naturalist to look to a præ-historic period for their development to have taken place in. And considering how strongly differenced are the Negro and the Syrian, and how slowly such changes of complexion and feature take place within historical experience, this præ-historic period was probably of vast length. The evidence from the languages of the world points in the same direction. In times of ancient history we already meet with families of languages, such as the Aryan and the Semitic, and as later history goes on many other families of language come into view, such as the Bantu or Kafir of Africa, the Dravidian of South India, the Malayo-Polynesian, the Algonquin of North America, and other families. But what we do not find is the parent language of any of these families, the original language which all the other members are dialects of, so that this parent tongue should stand towards the rest in the relation which Latin holds to its descendants, Italian and French. It is, however, possible to work back by the method of philological comparison, so as to sketch the outlines of that early Aryan tongue which must have existed to produce Sanskrit and Persian, Greek and Latin, German, Russian, and Welsh, or the outlines of that early Semitic tongue which must have existed to produce Assyrian, Phœnician, Hebrew, and Arabic. Though such theoretical reconstructions of parent languages from their descendants may only show a vague and shadowy likeness to the reality, they give some idea of it. And what concerns us here is that theoretical early Aryan and Semitic, or other such reconstructed languages, do not bring our minds appreciably nearer to really primitive forms of speech. However far we get back, the signs of development from still earlier stages are there. The roots have mostly settled into forms which no longer show the reasons why they were originally chosen, while the inflexions only in part preserve traces of their original senses, and the whole structure is such as only a long-lost past can account for. To illustrate this important point, let us remember the system of grammatical gender in Greek or German, how irrationally a classification by sex is applied to sexless objects and thoughts, while even the use of a neuter gender fails to set the confusion straight, and sometimes even twists it with a new perversity of its own. Many a German and Frenchman wishes he could follow the example of our English forefathers who, long ago, threw overboard the whole worthless cargo of grammatical gender. But looking at gender in the ancient grammars, it must be remembered that human custom is hardly ever wilfully absurd, its unreasonableness usually arising from loss or confusion of old sense. Thus it can hardly be doubted that the misused grammatical gender

in Hebrew or Greek is the remains of an older and reasonable phenomenon of language; but if so, this must have belonged to a period earlier than we can assign to the theoretical parent language of either. Lastly, the development of civilisation requires a long period of præ-historic time. Experience and history show that civilisation grew up gradually, while every age preserves recognisable traces of the ages which went before. The woodman's axe of to-day still retains much of the form of its ancestor—the stone celt in its wooden handle; the mathematician's tables keep up in their decimal notation a record of the early ages when man's ten fingers first taught him to count; the very letters with which I wrote these lines may be followed back to the figures of birds and beasts and other objects drawn by the ancient Egyptians, at first as mere picture writing to denote the things represented. Yet, when we learn from the monuments what ancient Egyptian life was like towards 5,000 years ago, it appears that civilisation had already come on so far that there was an elaborate system of government, an educated literary priesthood, a nation skilled in agriculture, architecture, and metal work. These ancient Egyptians, far from being near the beginning of civilisation, had, as the late Baron Bunsen held, already reached its halfway house. This eminent Egyptologist's moderate estimate of man's age on the earth at about 20,000 years has the merit of having been made on historical grounds alone, independently of geological evidence, for the proofs of the existence of man in the quaternary or mammoth period had not yet gained acceptance.

My purpose in briefly stating here the evidence of man's antiquity derived from race, language, and culture is to insist that these arguments stand on their own ground. It is true that the geological argument from the implements in the drift-gravels and bone-caves, by leading to a general belief that man is extremely ancient on the earth, has now made it easier to anthropologists to maintain a rationally satisfactory theory of the race-types and mental development of mankind. But we should by no means give up this vantage ground, though the ladder we climbed by should break down. Even if it could be proved that the flint implements of Abbeville or Torquay were really not so ancient as the pyramids of Egypt, this would not prevent us from still assuming, for other and sufficient reasons, a period of human life on earth extending many thousand years farther back.

It is an advantage of this state of the evidence that it to some extent gets rid of the 'sensational' element in the problem of fossil man, which it leaves as merely an interesting inquiry into the earliest known relics of savage tribes. Geological criticism has not yet absolutely settled either way the claims of the Abbé Bourgeois' flints from Thénay to be of Miocene date, or of Mr. Skertchly's from Brandon to be Glacial. The accepted point is that the men who made the ordinary flint implements of the drift lived in the quaternary period characterised by the presence of the mammoth in our part of Europe. More than one geologist, however, has lately maintained that this quaternary period was not of extreme antiquity. The problem is at what distance from the present time the drift-gravels on the valley slopes can have been deposited by water action up to one hundred feet or so above the present flood-levels. It does not seem the prevailing view among geologists that rivers on the same small scale as those at present occupying mere ditches in the wide valley-floors could have left these deposits on the hill sides at a time when they had not yet scooped out the valleys to within fifty or a hundred feet of their present depth. Indeed, such means are insufficient out of all proportion to the results, as a mere look down from the hill-tops into such valleys is enough to show. Geologists connect the deposit of the high drift-gravels with the subsidence and elevation of the land, and the powerful action of ice and water at the close of the Glacial age; and the term 'Pluvial period' is often used to characterise this time of heavy rainfall and huge rivers. It was then that the rude stone implements of palæolithic man were imbedded in the drift-gravels with the remains of the mammoth and fossil rhinoceros, and we have to ask what events have taken place in these regions since? The earth's surface has been altered to bring the land and water to their present levels, the huge animals became extinct, the country was inhabited by the tribes whose relics belong to the neolithic or polished-stone age, and afterwards the metal-using Keltic nations possessed the land, their arrival being fixed as previous to 400 B.C., the king of the Gauls then

being called by the Romans by the name *Brennus*, which is simply the Keltic word for 'king'—in modern Welsh *brenin*. To take in this succession of events geologists and archæologists generally hold that a long period is required. Yet there are some few who find room for them all in a comparatively short period. I will mention Principal Dawson, of Montreal, well known as a geologist in this Association, and who has shown his conviction of the soundness of his views by adressing them to the general public in a little volume entitled 'The Story of the Earth and Man.' Having examined the gravels of St.-Acheul, on the Somme, where M. Boucher de Perthes found his celebrated drift implements, it appeared to Dr. Dawson that, taking into account the probabilities of a different level of the land, a wooded condition of the country and greater rainfall, and a glacial filling up of the Somme valley with clay and stones subsequently cut out by running water, the gravels could scarcely be older than the Abbeville peat, and the age of this peat he estimates as perhaps less than four thousand years. Within this period Dr. Dawson includes a comparatively rapid subsidence of the land, with a partial re-elevation, which left large areas of the lower grounds beneath the sea. This he describes as the geological deluge which separates the post-glacial period from the modern, and the earlier from the later prehistoric period of the archæologists.

My reason for going here into these computations of Dr. Dawson's is that the date about 2200 B.C., to which he thus assigns these great geological convulsions, is actually within historic times. In Egypt successive dynasties had been reigning for ages, and the pyramids had long been built; while in Babylonia the old Chaldæan kings had been raising the temples whose ruins still remain. That is to say, we are asked to receive, as matter of geology, that stupendous geological changes were going on not far from the Mediterranean, including a final plunge of I know not how much of the earth's surface beneath the waters, and yet national life on the banks of the Nile and the Euphrates went on unbroken and apparently undisturbed through it all. To us in this Section it is instructive to see how the free use of paroxysms and cataclysms makes it possible to shorten up geological time. Accustomed as we are to geology demanding periods of time which often seem to history exorbitant, the tables are now turned, and we are presented with the unusual spectacle of chronology protesting against geology for encroaching on the historical period.

In connection with the question of quaternary man, it is worth while to notice that the use of the terms 'primæval' or 'primitive' man, with reference to the savages of the mammoth period, seems sometimes to lead to unsound inferences. There appears no particular reason to think that the relics from the drift-beds or bone-caves represent man as he first appeared on the earth. The contents of the caves especially bear witness to a state of savage art, in some respects fairly high, and which may possibly have somewhat fallen off from an ancestral state in a more favourable climate. Indeed, the savage condition generally, though rude and more or less representing early stages of culture, never looks absolutely primitive, just as no savage language ever has the appearance of being a primitive language. What the appearance and state of our really primæval ancestors may have been seems too speculative a question, until there shall be more signs of agreement between the anthropologists, who work back by comparison of actual races of man toward a hypothetical common stock, and the zoologists, who approach the problem through the species adjoining the human. There is, however, a point relating to the problem to which attention is due. Naturalists not unreasonably claim to find the geographical centre of man in the tropical regions of the old world inhabited by his nearest zoological allies, the anthropomorphous apes, and there is at any rate force enough in such a view to make careful quest of human remains worth while in those districts, from Africa across to the Eastern Archipelago. Under the care of Mr. John Evans a fund has been raised for excavations in the caves of Borneo by Mr. Everett, and though the search has as yet had no striking result, money is well spent in carrying on such investigations in likely equatorial forest regions. It would be a pity that for want of enterprise a chance, however slight, should be missed of settling a question so vital to anthropology.

While the problem of primitive man thus remains obscure, a somewhat more

distinct opinion may be formed on the problem of primitive civilised man. When it is asked what races of mankind first attained to civilisation, it may be answered that the earliest nations known to have had the art of writing, the great mark of civilisation as distinguished from barbarism, were the Egyptians and Babylonians, who in the remotest ages of history appear as nations advanced to the civilised stage in arts and social organisation. The question is, Under what races to class them? What the ancient Egyptians were like is well known from the monuments, which show how closely much of the present fellah population, as little changed in features as in climate and life, represent their ancestors of the times of the Pharaohs. Their reddish-brown skin, and features tending toward the negroid, have led Hartmann, the latest anthropologist who has carefully studied them, to adopt the classification of them as belonging to the African rather than the Asiatic peoples, and specially to insist on their connection with the Berber type, a view which seems to have been held by Blumenbach. The contrast of the brown Egyptians with the dark-white Syro-Arabians on their frontiers is strongly marked, and the portraits on the monuments show how distinctly the Egyptian knew himself to be of different race from the Semite. Yet there was mixture between the two races, and what is most remarkable, there is a deep-seated Semitic element in the Egyptian language, only to be accounted for by some extremely ancient and intimate connection. On the whole, the Egyptians may be a mixed race, mainly of African origin, perhaps from the southern Somali-land, whence the Egyptian tradition was that the gods came, while their African type may have since been modified by Asiatic admixture. Next, as to the early relations of Babylonia and Media, a different problem presents itself. The languages of these nations, the so-called Akkadian and the early Medic, were certainly not of the same family with either the Assyrian or the Persian which afterwards prevailed in their districts. Their connection with the Tatar or Turanian family of languages, asserted twenty years ago by Oppert, has since been further maintained by Lenormant and Sayce, and seems, if not conclusively settled, at any rate to have much evidence for it, not depending merely on similarity of words, such as the term for 'god,' Akkadian *dingira*, being like the Tatar *tengri*, but also on similarity of pronouns and grammatical structure by post-positions. Now language, though not a conclusive argument as to race, always proves more or less as to connection. The comparison of the Akkadian language to that of the Tatar family is at any rate *primâ facie* evidence that the nations who founded the ancient civilisation of Babylonia, who invented the cuneiform writing, and who carried on the astronomical observations which made the name of Chaldæan famous for all time, may have been not dark-white peoples like the Assyrians who came after them, but perhaps belonged to the yellow race of Central Asia, of whom the Chinese are the branch now most distinguished in civilisation. M. Lenormant has tried to identify among the Assyrian bas-reliefs certain figures of men whose round skulls, high cheek-bones, and low-bridged noses present a Mongoloid type contrasting with that of the Assyrians. We cannot, I think, take this as proved, but at any rate in these figures the features are not those of the aquiline Semitic type. The bronze statuette of the Chaldæan king called Gudea, which I have examined with Mr. Pinches at the British Museum, is also, with its straight nose and long thin beard, as un-Assyrian as may be. The anthropological point towards which all this tends is one of great interest. We of the white race are so used to the position of leaders in civilisation, that it does not come easy to us to think we may not have been its original founders. Yet the white race, whether the dark-whites, such as Phœnicians or Hebrews, Greeks or Romans, or the fair-whites, such as Scandinavians and Teutons, appear in history as followers and disciples of the Egyptians and Babylonians who taught the world writing, mathematics, philosophy. These Egyptians and Babylonians, so far as present evidence reaches, seem rather to have belonged to the races of brown and yellow skin than to the white race.

It may be objected that this reasoning is in several places imperfect, but it is the use of a departmental address not only to lay down proved doctrines, but to state problems tentatively as they lie open to further inquiry. This will justify my calling attention to a line of argument which, uncertain as it at present is, may

perhaps lead to an interesting result. So ancient was civilisation among both Egyptians and Chaldæans, that the contest as to their priority in such matters as magical science was going on hotly in the classic ages of Greece and Rome. Looking at the literature and science, the arts and politics, of Memphis and of Ur of the Chaldees, both raised to such height of culture near 5,000 years ago, we ask, were these civilisations not connected, did not one borrow from the other? There is at present a clue which, though it may lead to nothing, is still worth trial. The hint of it lies in a remark by Dr. Birch as to one of the earliest of Egyptian monuments, the pyramid of Kochome, near Sakkara, actually dating from the first dynasty, no doubt beyond 3000 B.C., and which is built in steps like the seven-storied Babyonian temples. Two other Egyptian pyramids, those of Abu-sir, are also built in steps. Now whether there is any connection between the building of these pyramids and the Babylonian towers, does not depend on their being built in stages, but in the number of these stages being seven. As to the Babylonian towers, there is no doubt, for though Birs-Nimrud is now a ruinous heap, the classical descriptions of such temples, and the cuneiform inscriptions, put it beyond question that they had seven stages, dedicated to the seven planets. As to the Egyptian pyramids, the archæologists Segato and Masi positively state of one step-pyramid of Abu-sir, that it had seven decreasing stages, while, on the other hand, Vyse's reconstruction of the step-pyramid of Sakkara shows there only six. Considering the ruinous state of all three step-pyramids, it will require careful measurement to settle whether they originally had seven stages or not. If they had, the correspondence cannot be set down to accident, but must be taken to prove a connection between Chaldæa and Egypt as to the worship of the seven planets, which will be among the most ancient links connecting the civilisations of the world. I hope by thus calling attention to the question, to induce some competent architect visiting Egypt to place the matter beyond doubt, one way or the other.

While speaking of the high antiquity of civilisation in Egypt, the fact calls for remark, that the use of iron as well as bronze in that country seems to go back as far as historical record reaches. Brugsch writes in his 'Egypt under the Pharaohs,' that Egypt throws scorn on the archæologists' assumed successive periods of stone, bronze, and iron. The eminent historian neglects, however, to mention facts which give a different complexion to the early Egyptian use of metals, namely, that chipped flints, apparently belonging to a prehistoric Stone Age, are picked up plentifully in Egypt, while the sharp stones or stone knives used by the embalmers seem also to indicate an earlier time when these were the cutting instruments in ordinary use. Thus there are signs that the Metal Age in Egypt, as elsewhere in the world, was preceded by a Stone Age, and if so, the high antiquity of the use of metal only throws back to a still higher antiquity the use of stone. The ancient iron-working in Egypt is, however, the chief of a group of facts which are now affecting the opinions of anthropologists on the question whether the Bronze Age everywhere preceded the Iron Age. In regions where, as in Africa, iron ore occurs in such a state that it can after mere heating in the fire be forged into implements, the invention of iron-working would be more readily made than that of the composite metal bronze, which perhaps indicates a previous use of copper, afterwards improved on by an alloy of tin. Professor Rolleston, in a recent address on the Iron, Bronze, and Stone Ages, insists with reason that soft iron may have been first in the hands of many tribes, and may have been superseded by bronze as a preferable material for tools and weapons. We moderns, used to fine and cheap steel, hardly do justice to the excellence of bronze, or gun-metal as we should now call it, in comparison with any material but steel. I well remember my own surprise at seeing in the Naples Museum that the surgeons of Herculaneum and Pompeii used instruments of bronze. It is when hard steel comes in, that weapons both of bronze and wrought iron have to yield, as when the long soft iron broad-swords of the Gauls bent at the first blow against the pikes of Flaminius' soldiers. On the whole, Professor Virchow's remarks in the Transactions of the Berlin Anthropological Society for 1876, on the question whether it may be desirable to recognise instead of three only two ages, a Stone Age and a Metal Age, seem to put the matter on a fair footing. Iron may have been known as early as bronze or even earlier, but nevertheless there have been periods in the life of nations when bronze, not iron,

has been the metal in use. Thus there is nothing to interfere with the facts resting on archæological evidence, that in such districts as Scandinavia or Switzerland a Stone Age was at some ancient time followed by a Bronze Age, and this again by an Iron Age. We may notice that the latter change is what has happened in America within a few centuries, where the Mexicans and Peruvians, found by the Spaniards living in the Bronze Age, were moved on into the Iron Age. But the question is whether we are to accept as a general principle in history the doctrine expounded in the poem of Lucretius, that men first used boughs and stones, that then the use of bronze became known, and lastly iron was discovered. As the evidence stands now, the priority of the Stone Age to the Metal Age is more firmly established than ever, but the origin of both bronze and iron is lost in antiquity, and we have no certain proof which came first.

Passing to another topic of our science, it is satisfactory to see with what activity the comparative study of laws and customs, to which Sir Henry Maine gave a new starting-point in England, is now pursued. The remarkable inquiry into the very foundations of society in the structure of the family, set afoot by Bachofen in his 'Mütterrecht,' and M'Lennan in his 'Primitive Marriage,' is now bringing in every year new material. Mr. L. H. Morgan, who, as an adopted Iroquois, became long ago familiar with the marriage-laws and ideas of kinship of uncultured races, so unlike those of the civilised world, has lately made, in his 'Ancient Society,' a bold attempt to solve the whole difficult problem of the development of social life. I will not attempt here any criticism of the views of these and other writers on a problem where the last word has certainly not been said. My object in touching the subject is to mention the curious evidence that can still be given by rude races as to their former social ties, in traditions which will be forgotten in another generation of civilised life, but may still be traced by missionaries and others who know what to seek for. Thus, such inquiry in Polynesia discloses remarkable traces of a prevalent marriage-tie which was at once polygamous and polyandrous, as where a family of brothers were married jointly to a family of sisters; and I have just noticed in a recent volume on 'Native Tribes of South Australia,' a mention of a similar state of things occurring there. As to the general study of customs, the work done for years past by such anthropologists as Professor Bastian, of Berlin, is producing substantial progress. Among recent works I will mention Dr. Karl Andree's 'Ethnologische Parallelen' and Mr. J. A. Farrer's 'Primitive Manners.' In the comparison of customs and inventions, however, the main difficulty still remains to be overcome, how to decide certainly whether they have sprung up independently alike in different lands through likeness in the human mind, or whether they have travelled from a common source. To show how difficult this often is, I may mention the latest case I have happened to meet with. The Orang Dongo, a mountain people in the Malay region, have a custom of inheritance that when a man dies the relatives each take a share of the property, and the deceased inherits one share for himself, which is burnt or buried for his ghost's use, or eaten at the funeral feast. This may strike many of my hearers as quaint enough and unlikely to recur elsewhere; but Mr. Charles Elton, who has special knowledge of our ancient legal customs, has pointed out to me that it was actually old Kentish law, thus laid down in Law-French:—'Ensement seient les chateus de gauylekendeys parties en treis apres le exequies e les dettes rendues si il y est issue mulier en vye, issi que la mort eyt la une partie, e les fitz e les filles muliers lautre partie e la femme la tierce partie.'—'In like sort let the chattels of gavelkind persons be divided into three after the funeral and payment of debts if there be lawful issue living, so that the deceased have one part, and the lawful sons and daughters the other part, and the wife the third part.' The Church had indeed taken possession, for pious uses, of the dead man's share of his own property; but there is good Scandinavian evidence that the original custom before Christian times was for it to be put in his burial-mound. Thus the rite of the rude Malay tribe corresponds with that of ancient Europe, and the question which the evidence does not yet enable us to answer, is whether the custom was twice invented, or whether it spread east and west from a common source, perhaps in the Aryan district of Asia.

It remains for me to notice the present state of Comparative Mythology, a most

interesting, but also most provoking part of Anthropology. More than twenty years ago a famous essay, by Professor Max Müller, made widely known in England how far the myths in the classical dictionary and the story-books of our own lands might find their explanation in poetic nature-metaphors of sun and sky, cloud and storm, such as are preserved in the ancient Aryan hymns of the Veda. Of course it had been always known that the old gods and heroes were in some part personifications of nature—that Helios and Okeanos, though they walked and talked and begat sons and daughters, were only the Sun and Sea in poetic guise. But the identifications of the new school went farther. The myth of Endymion became the simple nature-story of the setting Sun meeting Selene the Moon; and I well remember how, at the Royal Institution, the aged scholar, Bishop Thirlwall, grasped the stick he leant on, as if to make sure of the ground under his feet, when he heard it propounded that Erinys, the dread avenger of murder, was a personification of the Dawn discovering the deeds of darkness. Though the study of mythology has grown apace in these later years, and many of its explanations will stand the test of future criticism, I am bound to say that mythologists, always an erratic race, have of late been making wilder work than ever with both myth and real history, finding mythic suns and skies in the kings and heroes of old tradition, with dawns for love-tales, storms for wars, and sunsets for deaths, often with as much real cogency as if some mythologist a thousand years hence should explain the tragic story of Mary Queen of Scots as a nature-myth of a beauteous Dawn rising in splendour, prisoned in a dark cloud-island, and done to death in blood-red sunset. Learned treatises have of late, by such rash guessings, shaken public confidence in the more sober reasonings on which comparative mythology is founded, so that it is well to insist that there are cases where the derivation of myths from poetic metaphors is really proved beyond doubt. Such an instance is the Hindu legend of King Bali, whose austerities have alarmed the gods themselves, when Vâmana, a Brahmanic Tom Thumb, begs of him as much land as he can measure in three steps; but when the boon is granted, the tiny dwarf expands gigantic into Vishnu himself, and striding with one step across the earth, with another across the air, and a third across the sky, drives the king down into the infernal regions, where he still reigns. There are various versions of the story, of which one may be read in Southey; but in the ancient Vedic hymns its origin may be found when it was not as yet a story at all, only a poetic metaphor of Vishnu, the Sun, whose often-mentioned act is his crossing the airy regions in his three strides. 'Vishnu traversed (the earth), thrice he put down his foot; it was crushed under his dusty step. Three steps hence made Vishnu, unharmed preserver, upholding sacred things.'

Both in the savage and civilised world there are many myths which may be plainly traced to such poetic fancies before they have yet stiffened into circumstantial tales; and it is in following out these, rather than in recklessly guessing myth-origins for every tradition, that the sound work of the mythologist lies. The scholar must not treat such nature-poetry like prose, spoiling its light texture with too heavy a grasp. In the volume published by our new Folk-Lore Society, which has begun its work so well, Mr. Lang gives an instance of the sportive nature-metaphor which still lingers among popular story-tellers. It is Breton, and belongs to that wide-spread tale of which one version is naturalised in England as 'Dick Whittington and his Cat.' The story runs thus:—The elder brother has the cat, while the next brother, who has a cock left him, fortunately finds his way to a land where (there being no cocks) the king has every night to send chariots and horses to bring the dawn; so that here the fortunate owner of Chanticleer has brought him to a good market. Thus we see that the Breton peasant of our day has not even yet lost the mythic sense with which his remote Aryan ancestors could behold the chariots and horses of the dawn. But myth, though largely based on such half-playful metaphor, runs through all the intermediate stages which separate poetic fancy from crude philosophy embodied in stories seriously devised as explanations of real facts. No doubt many legends of the ancient world, though not really history, are myths which have arisen by reasoning on actual events, as definite as that which, some four years ago, was terrifying the peasant mind in North Germany, and especially in Posen. The report had spread far and wide that all Catholic children with black hair and blue eyes were to be sent out of the country, some said to

Russia, while others declared that it was the King of Prussia who had been playing cards with the Sultan of Turkey, and had staked and lost 40,000 fair-haired, blue-eyed children; and there were Moors travelling about in covered carts to collect them; and the schoolmasters were helping, for they were to have five dollars for every child they handed over. For a time the popular excitement was quite serious: the parents kept the children away from school and hid them, and when they appeared in the streets of the market-town the little ones clung to them with terrified looks. Dr. Schwartz, the well-known mythologist, took the pains to trace the rumour to its sources. One thing was quite plain, that its prime cause was that grave and learned body, the Anthropological Society of Berlin, who, without a thought of the commotion they were stirring up, had, in order to class the population as to race, induced the authorities to have a census made throughout the local schools, to ascertain the colour of the children's skin, hair, and eyes. Had it been only the boys, to the Government inspection of whom for military conscription the German peasants are only too well accustomed, nothing would have been thought of it; but why should the officials want to know about the little girls' hair and eyes? The whole group of stories which suddenly sprang up were myths created to answer this question; and even the details which became embodied with them could all be traced to their sources, such as the memories of German princes selling regiments of their people to pay their debts, the late political negotiations between Germany and Russia, &c. The fact that a caravan of Moors had been travelling about as a show accounted for the covered carts with which they were to fetch the children; while the schoolmasters were naturally implicated, as having drawn up the census. One schoolmaster, who evidently knew his people, assured the terrified parents that it was only the children with blue hair and green eyes that were wanted—an explanation which sent them home quite comforted. After all, there is no reason why we should not come in time to a thorough understanding of mythology. The human mind is much what it used to be, and the principles of myth-making may still be learnt from the peasants of Europe.

When, within the memory of some here present, the Science of Man was just coming into notice, it seemed as though the study of races, customs, traditions, were a limited though interesting task, which might after a few years come so near the end of its materials as no longer to have much new to offer. Its real course has been far otherwise. Twenty years ago it was no difficult task to follow it step by step; but now even the yearly list of new anthropological literature is enough to form a pamphlet, and each capital of Europe has its Anthropological Society in full work. So far from any look of finality in anthropological investigations, each new line of argument but opens the way to others behind, while these lines tend as plainly as in the sciences of stricter weight and measure, toward the meeting ground of all sciences in the unity of nature.

The following Report and Papers were read:—

1. *Report of the Committee for conducting Excavations at Portstewart and elsewhere in the North of Ireland.* See Reports, p. 171.

2. *On Flint Implements from the Valley of the Bann.* *By* W. J. Knowles.

The author has obtained within the last three or four years, from the banks of the river Bann, a series of flint weapons or tools which differ considerably in type from the ordinary flint implements of the North of Ireland. They have been obtained from a deposit of diatomaceous earth used for brickmaking near the town of Portglenone, and are of two types. That which is most numerous appears to have been made by splitting nodules into halves or quarters and then forming these into rude pointed implements by a process of coarse chipping. This kind numbers upwards of 50, and they all agree in having a cutting point, and thick base for

holding in the hand. They are, as a rule, long, narrow, and of a cylindrical form, rather than broad and flat, but some of the latter kind occur. Some of the largest are 7 or 8 inches long, and from 2 to 3 inches broad at the base, and there is one very fine implement of the flat kind, resembling the triangular Palæolithic implements, which is 6 inches long, nearly 4 inches broad at the base and 1½ inch thick. Dr. Evans, in 'Stone Implements and Ornaments of Great Britain,' mentions that he has found implements of Palæolithic form on the shores of Lough Neagh, near Toome. The author has also found similar implements at that place; but as Toome is only a little farther up the Bann, and the diatomaceous earth is found there, he believes they have been obtained from that deposit by denudation.

The second set of objects may be described as large triangular flakes with a central rib down the back and having the base wrought into a tang. In the Catalogue of the Royal Irish Academy, this form of implement is represented in Fig. 3, the tang being looked on as the first step in the process of development into arrow and spear heads; but the author is of opinion that instead of showing a step towards greater perfection these were perfect implements of their kind, and also manufactured specially for use about rivers.

There is no means of determining the age of these objects, except some sort of estimate is formed from the fact of their being found in a deposit underlying the peat. If they are of Neolithic age, they are very interesting from being confined chiefly to a river valley and not being obtained where other Neolithic implements are found in abundance. This fact would, according to the author, suggest a reason for the large triangular flints of Palæolithic age being chiefly confined to the old river gravels, while the implements of the same age from the caves are so different. The implements of the pointed kind in all cases might not be for general use, but chiefly for the river valleys. They may probably have formed weapons for attacking the larger animals when they came down to drink, but the theory that they were used for breaking holes in ice is also a very likely one. The author believes that the tanged flakes were used mounted, probably for spearing fish, as suggested by Dr. Evans in 'Archæologia,' vol. xli. p. 401.

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3. *Notes on the Polynesian Race.* *By* C. Staniland Wake.

The object of the paper was to show that the statements of recent writers that the Polynesian Islanders are a scantily bearded race, and that they are not acquainted with the bow and arrow, are erroneous. The evidence of travellers was cited showing that the beard is fully developed with the natives of Penrhyn Island, the Gambier Islands, the Hervey Islands, the Society Islands, Savage Island, New Zealand, the Marquesas Islands, and the Sandwich Islands. It was shown also that the natives of some of the Ellice group of islands, which were populated from Samoa, wear the beard, and that the Tongans who visit Fiji cultivate considerable beards, in imitation of the Fijians, from which we may infer that the beardless character of the Samoans, who appear to be the parent stock of the Eastern Pacific islanders, is not owing to a natural defect.

As to the bow and arrow, it was shown that this weapon was formerly used by the Society Islanders, the Sandwich Islanders, and the Friendly Islanders, and that it was not unknown to the natives of Savage Island, the Ellice Islands, the Hervey Islands, and New Zealand. Its inefficiency as a weapon of war had, however, led to its abandonment, except in certain sports which were restricted to the chiefs. That it had not been derived by the Polynesians from the Papuans is proved by the word for 'bow,' *panah*, being the same in the Polynesian and Malayan languages, but different in that of Fiji.

As the bow was not known to the New Caledonians and Tasmanians, probably the Papuans were not acquainted with it at the date of their earliest migrations; and as the Polynesians used it only in their sports, it must have lost its warlike character before they left their early home in the Indian Archipelago.

In conclusion, the paper proposed the use of the term *Kānākā* as a name for the Polynesian race, instead of *Mahori*, a name recently introduced by Mr. Ranken;

justifying the proposal by reference to the meaning and derivation of the term *kānāka* or *tangata*, which denotes 'man' and 'mankind' in all the Polynesian dialects, and by the fact, that the Pacific Islanders are already known in the East as *Kanaks*.

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4. *On the Relations of the Indo-Chinese and Inter-Oceanic Races and Languages.* *By* A. H. Keane, *M.A.I.*

Recent ethnological research in Further India and Malaysia could not fail to affect the views hitherto entertained on the affinities of the peoples occupying this area. The discovery of a non-Mongolian fair type in Indo-China, connected in physique with the Western Asiatic type conventionally known as 'Caucasian,' and speaking polysyllabic untoned languages, introduces a distinctly new factor into the problem. An attempt is here made to show that this factor offers the true solution of the intricate questions connected with the mutual relations of all the Indo-Chinese and Inter-Oceanic peoples. The conclusions I have arrived at are briefly these:—

I. Two ethnical types, the fair and the yellow, have occupied Indo-China from the remotest times. The yellow, or Mongoloid, is represented by the Burmese, Khassias, Shans, Siamese, Laos, Annamese, mostly semi-civilised and settled, and all exclusively speaking monosyllabic toned languages. The fair, or Caucasian, varying from white to different shades of brown, is represented by the semi-civilised and settled Cambojans or Khmêrs, Khmêr-doms or 'Primitive Khmêrs,' Chams and Kûys, and by the unsettled hill-tribes collectively known as Mois, Khâs, Penongs, or Lolos, all speaking closely related polysyllabic untoned languages. The historical continuity of the fair type is shown by reference to the bas-reliefs of Ongkor-Vâht.

II. Malaysia and Western Polynesia were originally occupied by two dark autochthonous types, for the present to be held as distinct—the Papûans mainly in the East, the Negritos mainly in the West. The Negritos are still represented by *disjecta membra*—Aetas in the Philippines, Samangs in Malacca, 'Mincopies' in the Andaman Islands, Kalangs in Java, Karons in New Guinea, possibly by others in Borneo and Formosa. But elsewhere they have everywhere been rather supplanted than absorbed by the intruding fair and yellow races from Indo-China. The Papûans are still represented by compact masses—Nufors, Arfaks, Kiotapus, Koiaris, Waigiu, Aru, &c., in and about New Guinea; elsewhere they have rather been fused with than supplanted by the fair and yellow races, the fusion resulting in the so-called 'Alfuros' of Ceram, Timor, Jilolo, Mysol, and other islands west of New Guinea, and in the Melanesians of the Admiralty, New Hebrides, Solomon, Fiji, Loyalty, New Caledonia, and other islands east of New Guinea.

III. Western Malaysia is now almost exclusively occupied by the fair and yellow stocks from Indo-China, everywhere intermingled in diverse proportions, but the fair, as the earliest arrivals, everywhere forming the substratum. Where the yellow prevails, the outcome are the typical Malays of Malacca, Java, parts of Sumatra, Bali, Lombok, Coasts of Borneo, &c. Where the fair prevails, the outcome are the so-called 'Indonesians,' or 'Pre-Malays'—Battaks, Passumahs, Atyehs, Lampungs of Sumatra, Dyaks and Kayans of Borneo, the natives of Celebes, Nias, Poru, &c. Thus the Malay is not an organic, but essentially a mixed type, oscillating between the fair and yellow, and at the extremes imperceptibly merging in both.

IV. But though the Malay is ethnically a mixed type, its speech is unmixed in structure, and fundamentally related to the Cambojan and other languages spoken by the fair races of Further India. This relationship is established on a sound philological basis, and the morphology of all these tongues is shown to be identical. The Indo-Pacific (so-called 'Malayo-Polynesian') linguistic family is thus extended so as to embrace the polysyllabic untoned languages of Indo-China, as the source whence all the Oceanic branches derive. The total absence of the monosyllabic toned languages of the yellow races from the Oceanic area is accounted for, this remarkable fact affording the key to the order in which the prehistoric migrations took place from the mainland to the Archipelago.

V. The large brown race in almost exclusive possession of Eastern Polynesia (Samoans, Tahitians, Maoris, Hawaiians, Tonga and Marquesas islanders), is affiliated, not to the typical Malays, but to that element in Malaysia which diverges most from the Mongoloid and approaches nearest to the Caucasian type. The migration of the fair race from the Archipelago eastwards is shown to have taken place at an extremely remote epoch, before or simultaneously with the arrival of the yellow races from Further India, consequently before the evolution of the Malay type proper. Hence there are no true Malayan ethnical elements and no Mongol blood in Eastern Polynesia. The direct connection of the Eastern Polynesians with the Indonesians of Malaysia is further confirmed on linguistic, physical, and ethical grounds.

Conclusion. Excluding the dark races there are in the Indo-Chinese and Inter-Oceanic area two fundamentally distinct racial types only—the yellow or Mongolian, and the fair or Caucasian; and corresponding to them two fundamentally distinct forms of speech only—the Monosyllabic spoken *vario tono*, and the Polysyllabic spoken *recto tono*. All the rest is the outcome of incessant secular interminglings.

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5. *On a Classification of Languages on the Basis of Ethnology.* *By* Dr. Gustav Oppert.

All languages display either a concrete or an abstract tendency, and it is on this distinction that the author's classification is primarily based. Both the concrete and the abstract divisions are subdivided, each into two classes. The divisions of the *concrete* class are termed *heterologous* and *homologous*; while those of the *abstract* class are called *digeneous* and *trigeneous*. Further subdivisions are suggested. The author's views are developed in a work on Comparative Philology, recently published in Madras.

SATURDAY, AUGUST 23.

The following Papers and Report were read:—

1. *On the Manners and Customs of the People of Urua, Central Africa.* *By* Commander Cameron, *R.N.*

The author remarked that the king of this people, Cassango, claimed divine honours; that it was supposed by the people that on the death of one king his spirit entered the body of his successor; and that on the death of the monarch his wives, with the exception of one, who remained to be the pythoness of his successor, were buried alive with him, with savage rites. The course of a river is diverted to furnish a ready grave. Here the terrible sacrifice is made, and then the waters, sent back into their original course, flow over the dreadful tomb. It seems that the religion of these people centres round an idol which is said to be located in an immense jungle. Such is the reverence, or rather awe, in which the people hold this god that they fear to pronounce its name. None but the king may sacrifice to it, excepting the sovereign's sister, who is given to the idol as a wife. Priests, of course, guard the grove of this oracle; and smaller oracles, of which the people do not stand in so much awe, are consulted on matters of every day life. The ventriloquial powers of the wizards who carry those idols are exercised when the answers are given. A clearly defined caste prevails amongst the people. One chief may not sit down in the presence of another of superior grade. Each class wears a distinctive apron. Mutilation is common as a punishment. A story was told of one wife of the king offering to undergo the penalty of having her ears cut off if she might have a slave. The king took her at her word. The mutilation

was done without giving much apparent pain or vexation to the lady. The flow of blood is staunched by an application of boiling porridge. Their notions of propriety are peculiar, and will not allow them to cook at another person's fire, or to drink while another is looking on. Tattooing is an elaborate work of art in this curious country; and one of the punishments a husband may inflict on an insubordinate wife is to cut, say out of her arm, a portion of the pattern tattooed there. The lady is then obliged to stay at home. Attention was called to the skill of this rude people in communicating long messages to distant places by the beat of the drum. They employ, in fact, a kind of telegraphic system.

In Urua, weddings generally lasted three or four days. The author was present at one, and had an opportunity of witnessing the festivities. All the people in the village were assembled. Some men blowing pipes and beating drums stood in the centre of a great circle of people who danced around them, groaning and howling and making a great noise. This was kept up day and night. Suddenly at the end of the third day the bride came out of a hut dressed in all the finery the village could muster. She wore a small apron made of a piece of linen which had been given to the chief, and was adorned with feathers, beads, and shells. She was carried on the shoulders of a very stout woman, and supported by a woman on each side. She was brought into the middle of the dancing people and jumped up and down on the shoulders of the woman. A number of beads and shells were given to her, which she scattered about indiscriminately, and the people scrambled for them, as they were considered to possess some virtue as charms. The jumping up and down of the bride was carried on so energetically that the skin was completely worn off the shoulders of the woman who carried her. Then the husband, a great fellow, came in, picked up his bride, put her under his arm, and walked off with her.

The resemblance between the African names Zambesi and Chambesi, and that of a river called the Tambezi, suggested to the author the speculation that there might be some connection between the language of that part of Africa and the Malayan tongue. He could find no root for these words in the African languages. The Malays had been in Madagascar, and this led him to the supposition that they might have gone further west.

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2. *On the Native Races of the Head-Waters of the Zambesi.* *By* Major De Serpa Pinto.

The author gave an account of the people of Bihé and some tribes on the west side of the Zambesi River. The Bihé people are slightly cannibal, but never eat each other except on great occasions. On fête days a limited number of people are sacrificed and their flesh eaten, mixed with beef. The inhabitants of the Bihé district are not the original residents of that country. A hundred years ago it was a deserted country. The son of the King of Humbe came north with a great many followers to this country on a hunting excursion. An encampment was formed. The prince one day met a princess of the north in his travels, and resolved to marry her. She came to his camp, bringing with her a train of maidens. The princess of the north, who was a daughter of the King of Andulo, could not long be in her new country without having a following of her father's subjects who were attached to her. In like manner the King of Humbe's subjects emigrated to the north to live with the son of their king. Mixed marriages resulted, and the race of Bihé people were established under the native name of Muhumbes. This was only 100 years ago. They have rude manufactures in iron and fabrics. They were able to supply the traveller with 15,000 rude bullets. He further described two races who both live near the river Cuchibi, one a black race called the Ambuellas, and the other the Mucassequeres, a white race. These races contrasted strongly not only in their colour, but in their form and feature. The most impressive characteristic of the Mucassequeres is their extreme ugliness. Of the Ambuellas, on the other hand, the author speaks in terms of admiration. Their eyes do not retreat like those of the Mucassequeres, but are perfectly well set; their noses are

finely shaped; they have small mouths, and thin lips. The whole contour of the face is well designed. The author spoke of another race, a little further south, who, in the cultivation of their lands, were so far advanced as to avail themselves of irrigation.

3. *On the Native Races of Gaboon and Ogowé.* *By the* Comte Savorgnan De Brazza.

This was a verbal communication in French, on the races which the author had visited. He explained that the practice of cannibalism had been greatly exaggerated in descriptions of these peoples. He threw discredit on Du Chaillu's stories of human flesh being exposed for sale in the villages, and of the dead from disease being sold for food. They only partook of the flesh of their enemies killed in war, and it was part of their religious belief that to eat the heart of a brave would increase their own valour. These maligned tribes were capable of the most generous sentiments, and in the case of the author, not only did they show no desire to eat him, but they had shown him a devotion to which he owed his life. One day, when his escort failed him and he himself fell sick, he was befriended by a Fan chief, who, to procure him succour, put himself in the power of a tribe with whom he was at enmity. He went to the hostile tribe to seek help for the sick explorer whom he had left in the bush. The astonished hostile tribe were incredulous, and feared an ambush. The Fan chief, determined to stick by his European friend, offered himself as a hostage until the escort should return, and, by reason of some delay in their return, was near forfeiting the life he had thus put in peril. The author also gave an account of a pigmy race—the Akas—who are not attached to any place, but are a wandering people.

4. *Report of the Anthropometric Committee.* See Reports, p. 175.

MONDAY, AUGUST 25.

The following Papers were read:—

1. *On the Forms and Geographical Distribution of Ancient Stone Implements in India.* *By* V. Ball, *M.A., of the Geological Survey of India.*

In continuation of some remarks made on this subject at the last meeting of the Association in Dublin,[1] the author gave an account of the results at which he had since arrived from an examination of all the available *data*. These are, that the three classes into which the stone implements may be grouped occupy independent geographical tracts, which overlap one another towards the centre of the peninsula.

The geographical tracts, &c., characterised by the prevalence of one or other of the particular forms, when laid down on a map, show a remarkable coincidence with the limits of the areas of distribution of the non-Aryan races belonging to the several families whose waves of migration have contributed to form the lower strata of the population.

Thus the manufacturers of the polished celts are probably identical with the Kolarian races who entered India from the north-east and Burmah.

On the other hand the manufacturers of the flakes and cores of flint, chert, &c., appear to have entered the peninsula from the north-west, and may have belonged to the Dravidian family.

[1] Report for 1878, p. 588.

The identity of the manufacturers of the chipped quartzite implements which are found in Southern India is less clear, but suggestions regarding it were also offered by the author.

The paper was illustrated by diagrams, showing the principal forms of the stone implements which have hitherto been found in India, by a map showing the areas of distribution, and by some specimens.

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2. *On the Discovery of certain Pockets of Chipped Flints beneath the Peat on the Yorkshire Moors, near Halifax.* *By* JAMES W. DAVIS, *F.S.A.*, *F.G.S.*

The hilly country to the north and west of Halifax forms a part of the great Penine Anticlinal, which extends from the borders of Westmoreland southwards to Derbyshire. It is composed entirely of millstone grit rocks, except small exposures of Yoredale shales at Todmorden and Diggle. Thick massive beds of sandstone crown all the hill-tops, forming extensive plateaus with a regular dip towards the south-east. This plateau is broken through by the river Calder and its tributaries, exposing still greater thicknesses of shale beneath the several sandstones. The plateaus of grit rock are almost universally covered with heather and peat, the latter averaging from six to twelve feet in thickness. On these moorlands, north of Halifax, quarrying operations are carried on, and in the district about Warley Moor and Fly-flats, 1,200 to 1,300 feet above the sea level, discoveries have been made of numerous fragments of flint, evidently chipped from larger cores. They are found beneath the peat, near the surface of the rock. There is no locality nearer than the chalk wolds of East Yorkshire where the parent flints can be obtained *in situ*, and this leads to the inference that they were carried to their present situation for the purpose of manufacturing flint implements, and that this must have taken place a long time ago, from the great accumulation of peat above them.

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3. *On an elaborately finished Celt found on the Moors near Marsden.* *By* JAMES W. DAVIS, *F.S.A.*, *F.G.S.*

Several years since a smoothly-polished axe-head was found on the hills about a mile north-west of Marsden, whilst boring for an extension of quarrying operations. It was found beneath a considerable thickness of peat on the surface of the rock. The implement is flint, 5 inches long, $2\frac{1}{4}$ inches broad at the cutting end, and $1\frac{1}{4}$ inches thick about the centre, converging to a sharp edge at each end. The cutting edge is considerably fractured by use.

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4. *On some curious Leathern and Wooden Objects from Tullyreagh Bog, County Antrim.* *By* W. J. KNOWLES.

The author lately obtained from a workman some curious objects made of leather. One is the greater part of the hide of some animal very roughly tanned, out of which so many pieces have been cut of a diamond or oblong shape that what remains looks like a wide-meshed net. It was found surrounding a wooden vessel, made from a single piece of wood, and the thought has occurred to the author that it may have been used for surrounding heavy objects that required to be carried. It would be more suitable for that purpose, owing to its greater pliability, than a complete piece of hide. The other leathern object was a lid for another wooden vessel, also made from a single piece of wood. This vessel is still perfect, and measures 1 foot 4 inches in height, and is in diameter 1 foot 2 inches at top, and 1 foot 4 inches at bottom. The other vessel is broken up, but both contained, when found, what the workman described as a creamy substance, which flowed away when the vessels were taken out.

All these objects were found together during the time of cutting peat for fuel, about two months ago, and about 12 feet from the surface. They appeared to have been placed in a hole that had been excavated on the surface and then covered for protection, but being forgotten or lost, they remained where they were, it is believed, until 12 feet of peat accumulated over them.

5. *On Savage and Civilised Warfare. By* J. A. Farrer.

There is a superficial difference between savage and civilised warfare in their tactics, weapons, and usages; a civilised army does not actually worship a war-god, does not mutilate its dead foes, nor sacrifice nor torture its prisoners, and it generally spares the lives of women and children. Yet there is no such difference as to make the expression 'civilised warfare' other than the most flagrant contradiction in terms. Warfare can no more be civilised than a circle can be a square. Indeed, warfare is all the worse which claims to be civilised. The author traces the effect of military necessities on the political and religious development of savage races, and points out the links which connect modern warfare with barbarism. Lastly, he discusses the question whether mankind will ever be sufficiently advanced in civilisation to shake off the pursuit and lust of war.

6. *On the Origin of Fetishism. By* Andrew Lang.

Opposing Professor Max Müller's views, which regard Fetishism as a corruption of a higher religion, the author seeks to prove that it is a primitive form of belief in the supernatural, and represents one of the earliest factors in the development of religion. The paper will be published in 'Mind.'

7. *On certain Inventions illustrating the Working of the Human Mind, and on the Importance of the Selection of Types. By* A. Tylor, *F.G.S.*

Desire to economise mental and mechanical labour is one of the great sources of the invention of new thoughts. Nothing tends to save labour so much as using a type instead of a number of individual cases. The mind is burdened with masses of detail, and the system of types must be carried out for the arrangement of materials for thought. One of the most important aids to progress of every kind has been the art of choosing types. The invention of the Arabic numerals was a striking example of a perfect type-system. Examples are given in which the same kind of invention is applied to mental and to mechanical objects.

8. *On the Discovery of Animal Mounds in the Pyrenees. By* Dr. Phené, *F.S.A., F.G.S.*

The present discovery was very greatly due to the description given by Sir Vincent Eyre, in the 'Athenæum' (July 24, 1869) of a remarkable custom of burning living serpents at a particular spot in the Pyrenees. The author had long intended to make a more complete exploration of these mountains than former visits had enabled him to do, and in this case he determined to investigate all the districts around this spot of immolation. In doing so, he found in certain directions indications which always accompany these mounds. The churches abounded in features expressive of the subversion of a pagan faith of which the serpent or dragon had evidently been the representative, and with these were found built into the walls examples of pagan Roman occupation, as votive altars, &c., &c. Following the track where these were most expressive, he had come upon mounds as distinct in form to an animal appearance as that presented by any of the American mounds; they were altogether artificial, and shaped into an appearance of animal outline so real as to seem like life. In the parts forming the heads, the chamber had been appropriated, in one case by an arched chamber of Roman work, in

another by a descent of several feet into the body of a small church. On the spine of the least molested one had been a tumulus in which, the *curé* of the church informed him, had been found several of the most primitive incinerary urns, containing bones, Celtic articles, and above these, objects of the Gallo-Romano description, and again above these, later or Christian Roman works. One of the most interesting of the latter had been laid aside, and the *curé* sought it out for Dr. Phené amongst some *débris*; it was the stem of an ancient cross, and on it were sculptured serpents—not in the usual position of subjection to a superior power, but evidently as being in a condition of supremacy; but as there were also several dead ones represented, it might be that the sculpture figured the condition of the real serpents before and after the ceremony of burning. Everything in the district was emblematic of the serpent or dragon, and the mounds were distinctly of such a form. On the mountains overlooking these mounds were a number of stone circles, like those so well known in Britain. The description of these and further details he reserved to meet a request, made by the representatives of the American Congress at Brussels, to read a paper on the mounds of Europe. In this last discovery he had the advantage of having some members of the British Archæological Association present with him, who also identified the exact resemblance of the mounds with life-like animal forms.

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9. *Evidence of Early Historic Events and Pre-historic Customs by perpetuation of design in art and manufactures in later, and even in present, times.* *By* Dr. Phené, *F.S.A., F.G.S.*

The author admitted, in the outset, the difficulty of the subject, which he thought had not yet been opened. The sources of information were few, and the researches were consequently not to be pursued continuously, but caught up in other investigations as they occurred. He thought a large amount of matter was dormant in the hands of other inquirers, which, when a distinct channel was given to it, would arise in discussion and be found of great interest. As the further we go back in time the more difficult it is to identify causes or to determine events, he proposed to give such evidence as he had collected inversely, and beginning at the present to work gradually into the past, as by investigating familiar and existing examples, the more remote might, when brought forward, appear less confused by the mists of time.

He selected first the works of ordinary artizans, and took as an example the carpenter and joiner of the present day. He pointed out that in Western Europe all their ordinary work was made in a rectangular manner; ordinary doors and windows, for instance, were shown not only to be so formed, but designs and sections alike always produced that which the artizan never contemplated as a part of his work, but which he unthinkingly perpetuated from his forefathers, viz., the emblem of the faith of Europe—the Cross. It would not do to say this was the result of the simplest mode of construction, because in Asia, and even in Eastern Europe, it was argued with the same persistency that a curve was not only the most beautiful, but the easiest and simplest form of construction. Of course, the force of habit is great, and the artizan working continually in curved work finds it much easier than one only accustomed to the square. But the work in India, whether in plain solid work, such as had been taken as an example for Europe, or the delicate metal work, was always curved or interlaced; and the old religion of India was that of the serpent. In Persia the circular was always contending with the curved and the undulating design, and the contending religions there were the sun and serpent. In Turkey the designs, as for instance of the dome of a mosque, were formed of a series of crescents by omitting the intermediate ones of which separate crescents existed, which appeared hardly capable of producing the design. Every Turkish article, even to the oar and scimitar, was formed of more than one crescent, and the Christian sword was as great a contrast as the French window. Gothic and Byzantine work had been introduced among the artizans of Europe, but it had failed to grow upon the soil, and was clearly exotic. The author gave evidence that these arts were introduced by the Templars, the most cultivated

men of their day, but notoriously given to the old Pagan faiths, and who met with symbols of the old faith of their Pagan forefathers in their contact with Orientals. He considered there was abundant evidence from their design to attribute all interlaced work, and the sculptured stones of Britain and Ireland, to the influence and designs of the Templars. They all perpetuated, directly or indirectly, the form of the serpent. The author then examined the art of pre-Christian Rome—not in Rome itself, but in the countries where such art was significant of matters connected with them—in Gaul, Britain, the Campania, and others. In special countries, and even in particular districts of those countries, the grand object of Pagan Roman sculpture was the serpent or dragon. For example, the works of this class in Provence were abundant, but though more and better preserved Roman remains were to be found of the same date in Languedoc, as at Nimes, there was no indication of the serpent. Other emblems, used as standards by Gauls and Teutons were profusely shown in some of the early Roman sculptures in Provence, but they were nowhere perpetuated, showing that the great emblem—the greatest of their standards and, no doubt, therefore their chief deity—was the dragon. It was even adopted by the Popes in their dealings with Gaul, and in one notable instance they used only two emblems—the eagle of pagan Rome and the dragon of Gaul—and gave equal honour and position to both, as a compliment to the people of both countries, showing that these emblems of nationality were retained irrespective of the new faith. He had referred so much to the serpent or dragon simply because it was the most prominent object. The whole district he was treating of was *dragonesque*. He had lately officiated himself at a great dragon ceremony, in which the clergy of the district took the chief part. In this case, cakes in the form of the dragon were distributed; when the ceremony is abolished the form of these cakes will not be understood; all the ordinary loaves of the district were formed like sections of a creeping thing like a caterpillar. Nothing of the sort existed in the adjoining districts. The dragon was only appeased by the death of children. These things strongly pointed to immolation to a serpent deity. There were many other examples he could from want of time only enumerate. The schoolboy notches on a stick the number of runs at cricket; in doing so he perpetuates the old custom of the Exchequer. The baker of Brittany still notches a stick for the number of loaves he sells you, instead of making a bill. The milk and other tallies in England were till recently kept in the same way. This was, no doubt, a very old custom amongst the Gauls, and he (Dr. Phené) discovered in the former temple of Triptolemus, near Eleusis, two disused columns, the flutings of which, though rude and very ancient, gave the number of days of the week and month, in fact, formed a lunar calendar. Our schoolboys and Breton bakers of to-day had no idea they were perpetuating these ancient customs.

The disc found on the forehead of Dr. Schliemann's cow's head, or Hera, had been perpetuated by Greek sculptors, apparently without the meaning, and had subsequently been represented merely by the concentric form the hair of a cow or bull takes on the forehead; the exhumation of this antique showed it to have a special meaning. In the Persian mace he (Dr. Phené) produced, the cow's horns were gilt, showing, though the meaning had been lost, that the horns were those of the moon. This agreed also with the horns of Schliemann's Hera. In a bronze head of Isis he (Dr. Phené) had lately found, the crescent was between the cow's horns, and this was evidently the original emblem from which the Mahommedans of to-day derived their crescent and star; instead of giving a double crescent, as the horns and crescent if perpetuated would have done, they introduced the star; but your Mahommedan, although scrupulous in praying at sunrise and sunset, would repudiate the idea that he worshipped Astarte or Isis, and does not know that he uses the special symbol of those deities. The success of Mohammed was, no doubt, greatly attributable to this emblem, as all these scattered worshippers, finding their own deity debased, gathered round his standard. This emblem was, as he pointed out last year, found in Ireland, on a cow's head, of which he gave an illustration.

He exhibited a tile from the monastery at Patmos; it had three serpents—everything at Patmos had three serpents. He also exhibited a horse from Troy; no child at Troy would be content without a horse for a toy; it was the old Trojan

horse of the Iliad, which was shown by an antique bronze horse found in the plains of Argos, of exactly the same shape. A water-jug from Ephesus, made in that locality alone, was as much in the form of Diana of Ephesus as Dr. Schliemann's jugs were of Minerva, and modern jugs gave the form of the latter. A large Italian water-jug he had represented the sun and serpent, without any intention of the maker, but evidence of their worship abounded in the locality where the jug was made. These were evidences quite as expressive as the etchings on bones from the caves were of what the etchers saw being so portrayed by them.

TUESDAY, AUGUST 26.

The following Papers were read:—

1. *The Profile of the Ancient Greeks.* *By* J. Park Harrison, *M.A.*

Two theories have been propounded to account for the remarkable facial lines in early Greek sculpture, one deriving them from Hellenic models, the other assuming them to have been more or less ideal: and it is this latter view, in the absence of any trace of the feature in modern Greece (except, perhaps in some of the islands), joined with the fact that the ancient Greek crania are without the lines in question, that is now most commonly accepted.

The peculiarity in question consists in the absence of any nasal point, or, in other words, in the continuity of the lines of the brow and nasal bone, and in the close proximity of the mouth and nostril; in addition to which the upper lip is often curved, and the chin more or less massive.

Now if any superior race in point of culture, and possessing these features, could be shown to have had intercourse with the Greeks, when in a low state of civilisation, it would appear probable that the peculiarity was copied by them, rather than that it represented any abstract ideal of beauty, or some divine attribute unconnected with any living model.

When then we find examples of the feature in early monumental frescoes, and some of the more ancient crania from Egypt, in the portraits of Sidonians from the tombs of the Pharaohs, and in the remarkable busts on the covers of the Phœnician sarcophagi in the gallery of the Louvre at Paris, and the one from Sidon in the British Museum, as well as in the terra cotta statuettes from Camirus, Panormus, Tortosa, Calvi, Carthage, and other depôts and towns established by the Phœnicians, it seems probable that the early Greeks, who received their gods from the Phœnicians, gave them the features of this remarkable race. With varieties for age and sex, the images of the great gods in Greece all display the same facial lines. Unfortunately there are no skulls of a sufficiently early date in Phœnicia to complete the identification.

2. *On the Geological Evidence as to the Antiquity of Man.* *By* Professor W. Boyd Dawkins, *M.A.*, *F.R.S.*

The evidence which Geology has to offer as to the antiquity of man is as follows:—In the Eocene age there were only families and orders of living mammalia, and no living genera or species. It is, therefore, hopeless to look for man at this time in the earth's history. In the succeeding or Meiocene age living genera of mammals appear, but still no living species of mammalia.

If the flints found at Thenay, and supposed to prove the existence of Meiocene man, be artificial, and be derived from a Meiocene stratum, there is, to my mind, an insuperable difficulty in holding them to be the handiwork of man; seeing that no living species of quadruped was then alive, it is to me perfectly incredible that man, the most highly specialised of all, should have been living at that time. The flints shown to me in Paris by Professor Gandry appear to be artificial, while those in the Museum of St. Germains appear to be partly artificial and partly natural, some of the former, from their condition, having been obviously picked up on the

surface of the ground. It is less difficult to believe them to be the work of the large extinct anthropoid apes then living in France, than to view them as the work of man. The cuts on the Meiocene fossil bones discovered in several other localities in France may have been produced by other agencies than the hand of man.

Nor in the succeeding Pleiocene age is the evidence more convincing. The human skull found in a railway cutting at Olmo, in Northern Italy, and supposed to be of Pleiocene age, was associated with an implement, according to Mr. John Evans, of Neolithic age. Some of the cut fossil bones discovered in various parts of Lombardy, and considered by Professor Capellini to be Pleiocene, are undoubtedly produced by a cutting implement before they became mineralised, a point on which the examination of the specimens leaves me no reason for doubt. I do not, however, feel satisfied that the bones became mineralised in the Pleiocene age, and the fact that only one species of quadruped now alive then dwelt in Italy, renders it highly improbable that man was living at this time. This zoological difficulty seems to me insuperable.

The only other case which demands notice is that which is taken to establish the fact that man was living in the Interglacial age, in Switzerland. The specimens supposed to offer ground for this hypothesis consist of a few pointed sticks in Professor Rütimeyer's collection at Basle, of the shape and size of a rather thin cigar, crossed by a series of fibres running at right angles. They appear to me, after a careful examination, to present no mark of the hand of man, and to be merely the resinous knots which have dropped out of a rotten pine-trunk, and survived the destruction of the rest of the tree. As the evidence stands at present there is no proof, on the Continent or in this country, of man having lived in this part of the world before the middle stage of the Pleistocene age, when most of the living mammalia were then alive, and when mammoths, rhinoceroses, bisons, horses, and Irish elks, lions, hyænas, and bears haunted the neighbourhood of London, and were swept down by the floods of the Thames as far as Erith and Crayford.

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3. *On the Survival of the Neolithic Period at Brandon, Suffolk.* *By* Sydney B. J. Skertchly, *F.G.S., H.M. Geological Survey.*

This paper embodies the results of the author's researches into the origin of the gun-flint trade, still carried on at Brandon, in Suffolk. From Palæolithic times to the present day this locality has been renowned for the excellent quality of its flint, and during the Neolithic period flint was regularly mined for, just as it is at present. A careful study of the methods of mining, modes of working flint, of the tools used, and the implements made by the Neolithic and modern people reveals so many singular coincidences that the conclusion is drawn that the working of flint must have been carried on uninterruptedly in the vicinity of Brandon since Neolithic times. This opinion is further strengthened by the absence of the similarities in question from those gun-flint centres which are known to be of modern origin. The peculiar phraseology of the Brandon flint-knappers is also pointed out, and the suggestion made that some of these words may possibly prove to be of pre-Aryan stock.

The points of similarity between the ancient and modern arts are briefly as follows:—

1. *Mining.*—At Brandon flint is still mined for in a very primitive manner In the neighbourhood the remains of extensive Neolithic flint mines, known as Grime's Graves, are still extant, and a plan of one of these is like a bad drawing of a modern pit. There are also numerous old pits, whose age is unknown, but is certainly newer than Neolithic times, and they are sufficient in number to bridge over the interval between Neolithic and historic times. Moreover, those pits which are known to have been independently started about the time of the introduction of flint-locks, are, in other places, worked upon modern, and not ancient plans.

2. *Mining Tools.*—A very singular one-sided pick is used by the Brandon flint-

diggers, which seems to be derived from the deer-horn picks used by the Neolithic flint-diggers at Grime's Graves, of which a great number have been found.

3. *Flaking Hammer.*—The flaking hammer used by the Brandon flint-knappers, which is known as the English Hammer, seems also to have been derived from the Neolithic hammer. The peculiarities of these tools are pointed out.

4. *Implements.*—The strike-a-lights now made at Brandon are in many cases precisely similar to Neolithic specimens. The gun-flints have clearly been developed from strike-a-lights. The manufacture of strike-a-lights was the connecting link between the Neolithic tool trade and the gun-flint trade; and as strike-a-lights have nearly succumbed to lucifer matches, so have their offspring, the gun-flints, nearly become extinct before the percussion caps.

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4. *On the Stone Age in Japan. By* Professor JOHN MILNE, *F.G.S.*

The author describes, from personal examination, many of the archæological remains of Japan. Kitchen-middens are abundant. Lists of the shells and the bones which they contain are given, and the character of the associated pottery is minutely described. The middens are ascribed to the Ainos, and it is noticed that the ornamentation on the pottery resembles that still used by the Ainos of to-day. The stone implements found in Japan include axes, arrow-heads, and scrapers. Many of these occur in the middens. The axes are formed generally of a greenish stone, which appears to be a decomposed trachytic porphyry or andesite. It is pointed out that the Ainos used stone implements up to a comparatively modern date. Tumuli occur in many parts of Japan, and in some cases are associated with traditions. Of the many caves in Japan some are artificial, and their exploration promises a rich harvest to the cave-hunter. The paper also contains references to recent geological changes in Japan.

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5. *On a collection of Organic Remains from the Kitchen-middens of Hissarlik. By* Staff-Surgeon EDWARD L. MOSS, *R.N.*

The author remarked that whatever opinions may be held as to the site, or even as to the actual existence, of heroic Troy, there could be no question about the extreme interest attached to the Walled Acropolis, unearthed by Dr. Schliemann. It occupied the very spot at that stepping-off place between Asia and Europe where tradition had placed the ancient stronghold.

Dr. Schliemann had most liberally given him permission to collect some of the bones which were exposed in every yard of the excavations, but the accumulations were so extensive and of so many successive ages, that he had found it necessary to restrict himself to those immediately overlying the old wall. They consisted of charred and broken bones of deer, goat, sheep, ox, and boar, often marked by sharp cutting instruments, sometimes, as in an instance of a tibia of deer exhibited, converted into implements—worn astragali were common, and may have been used in the well-known children's game. He had seen no human bones except those of an unborn infant of about six months, enclosed in a pot with a quantity of, perhaps, unidentifiable calcined bones.

Bones of dog and of a small carnivora, like a weasel, were, no doubt, accidentally mixed up with the vestiges of the prehistoric feasts. Birds were represented in the collection by the tibia of a teal, and the leg and wing bones of a wader.

The very abundant molluscous remains consisted almost entirely of the edible genera now used everywhere on the shores of the Hellespont and Ægean, namely, cockle, oyster, mussel, limpet, whelk, pecten, solen, petunculus. A trochus and a bored columbella may have been used for ornament.

Most of the bones of pig were of young animals, in which the epiphyses had not become attached. The antlers of red deer often had the tip of the brow-line sawn off. They were generally cast antlers, or, at all events, knocked off near the cast-

ing time. Amongst vegetable remains the siliceous casts of large reeds, used to line the plaster of houses, should be noticed. Masses of carbonised wood were not uncommon, and carbonised peas or lentils were occasionally found in the domestic vessels.

All these remains occurred amongst quantities of rude potsherds,[1] amongst which spinning whorls were conspicuous—débris of stone and brick walls—the latter sometimes vitrefied as if they had formed the side or floor of a furnace. Dr. Schliemann's half of the worked gold and bronze, found in the same layer, has been generously deposited in South Kensington. The other half was the perquisite of the Turkish Government.

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6. *On High Africa as the Centre of a White Race.* *By* Hyde Clarke, *V.P.A.I.*

The object of this paper was to support a division proposed by the author between the Aryans and the other white races of early historical epoch. Treating the Akkad-Babylonians, Lydians, Canaanites, Etruscans, as the ancient types of the non-Aryan white races, he proposed as modern representatives the Georgians, Circassians, Armenians, Koords, Persians, Afghans, Greeks of Scioxa. The migrations and historical incidents of the non-Aryan whites were, he said, to be accounted for by a migration from Africa, and a habitat in High Africa. He showed that the languages of the great states of Africa belong to a like class with the Akkad, Lydian, Phrygian, Thracian, Etruscan, Georgian, &c. He referred also to the community of mythological origins. The traditions of Abyssinia treated it as a paradise, and the cradle of the world. To the white race he gave the name of Turano-African; and assigned to it the foundation of Egypt, of the great empires of Asia, and the kingdoms of Southern Europe and Northern Africa. He attributed to it not only a knowledge of North and South America and Australia, but also the occupation of those regions, the evidences of which are found in their languages, mythology, and monuments.

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7. *On the Turcomans between the Caspian and Merv.* *By* Professor Arminius Vambéry.

The Turcoman tribes inhabiting the western portion of the great Turanian desert, though split up into hostile divisions, have never lost their purity of race and language, and are Turks *par excellence*. They have avoided intermixture, and retain the genuine Turkish physical type, not exhibiting the peculiarities of those Turks who live in the north-east of Central Asia and form a transition to the Mongol race. The purest Turcoman type is found in the Tekehs (particularly the Tchaudors and Imolis), whilst the Goklans, a fraction of the Yomuts, and the Eusaris are the most degenerate. The Salars or Salors, a tribe now living to the south-east of Merv, are the first mentioned in history, and next to them, the Guz or Gozz, formerly living near the present Andkhoi.

According to modern philology, the Turcomans are nearest to the old Seljukians and the Osmanlis of to-day, the affinity being striking both as regards grammar and vocabulary: for instance, an Anatolian peasant can converse with greater ease with a Yomut or Goklan Turcoman than with an Azarbajani Turk, his near neighbour. It is supposed that the migrating Seljukians who founded the first Turkish principalities in Asia Minor were a brother tribe of the Turcomans who remained in their ancient seat, with gradual encroachments in its immediate neighbourhood.

The general characteristic of the Turcoman tribes is a surpassing love for a wandering life, resulting in the avoidance of any change (except in two isolated cases), owing to the influence of political revolutions or Buddhistic or Islamite culture, which have affected the Kazaks and other Turkish tribes. Thus they show a laxity in the observations of the Mohammedan tenets, and exhibit many

[1] Flint chips. (Flints are still used by the local housewife to grain her corn.)

remnants of the Shaman faith. Although superficially decidedly more savage than the tribes to the north and north-east, many of the fine qualities of the unsophisticated primitive life of the Turkish race are retained by them.

As to their number, it is believed that the figure of 1,000,000 is more likely to be increased than diminished by any statistics possible. The Tekehs are now the most numerous, and next to them the combined Yomuts of Khiva and on the Görgan. Those of the ancient tribes who from their position first came in contact with the political movement from Turan to Iran, were the first to diminish; and the Tekehs, heretofore sheltered by Persian anarchy, will now probably share the same fate under the Russian supremacy. They have always been fierce soldiers and dauntless adventurers.

Nothing can exceed the sterility and nakedness of the Turcoman steppes (Kara Kum, Ust-yust, Kizil-kum, &c.), which serve only as a temporary abode to the Kazaks, but are often used from necessity as a home by the Turcomans. The Yomuts in the south of Khiva have adopted a half settled life, tilling the soil and attending much to irrigation. They would do so still more, if not too severely taxed by the Khans of Khiva. Similar but weightier exactions have prevented the Tekehs and other tribes from settling on the Atreck, and in similar localities suitable for agriculture, and have given rise to devastating inroads by the Persians, repaid by foraging and plundering expeditions called Alaman. But as the Kazaks, formerly man-stealers and robbers, now permit unmolested intercourse to a certain extent, there is no reason why the Turcomans, if properly met, should not also abandon their cruel and plundering habits, especially as they still retain a rigid observance of their plighted word. They also show family love, respect females, practise hospitality, and have an ineradicable love of independence.

In considering the question of the difficulty of the roads from the Caspian to Merv, Professor Vambéry is of opinion that the Turcomans will not be so easy for the Russians to deal with as the Kazaks and Karchalpaks, though it required more than a century before these were brought under subjection. The Tekehs, whose country is now desired, are not only the most numerous but the most warlike of the tribes; and unless Russia has made up her mind for a war of extermination, the expenses of the present and any future campaign will be entirely thrown away. A peaceful solution of the question, whereby the Turcomans would have their independence secured as against Russia and Persia, would appear more satisfactory and feasible than the use of force.

DEPARTMENT OF ANATOMY AND PHYSIOLOGY.

CHAIRMAN OF THE DEPARTMENT.—P. H. PYE-SMITH, B.A., M.D.
Vice-President of the Section.

[For Dr. Pye Smith's Address see p. 406.]

THURSDAY, AUGUST 21.

The Department did not meet.

FRIDAY, AUGUST 22.

The following Papers were read:—

1. *Observations on the Automatic Mechanism of the Batrachian Heart.* *By* Professor J. BURDON SANDERSON, *M.D., F.R.S.*

2. *The Influence of Domestication on Brain-growth.* *By* W. F. CRICHTON BROWNE.

3. *On a Law of Retinal Activity.* *By* Professor SILVANUS P. THOMPSON, *B.A., D.Sc., &c.*

A memoir was read by the author in 1877 before the Physical Section of the Association 'On some new Optical Illusions,' some of which did not appear to accord with any explanation hitherto offered. The illusions in question are those of the subjective motion observed in apparent existence after the eye has for some time been fixed upon a moving object, and which are executed, apparently in an opposite direction. The most striking of these illusions are those produced by slight movements given to certain patterns of lines and circles drawn in black upon a white ground, and described in the author's memoir. The oldest illusions of apparent motion are those recorded by R. Addams and by Brewster. While pointing out that persistence of the retinal images failed to account for the production of these illusions, the author abstained from advancing any completed theory until experimental evidence was more complete.

Quite recently Dr. Javal, Director of the Ophthalmological Laboratory of the Sorbonne, has advanced an explanation of a different nature. He refers the production of the subjective sensation of motion to small muscular movements uncon-

sciously executed by the eyeballs attempting to follow the real movements, and continuing their unconscious slipping afterwards, so causing apparent motion in objects that are really stationary. The theory of Dr. Javal, however, appears to be untenable in the presence of two facts of capital importance: *first*, that the illusion of apparent motion is confined to objects occupying that portion of the visual field occupied before by the moving body; *secondly*, that if two or more simultaneous motions occur in different directions, in different parts of the visual field, each produces its own illusive motion in a complementary direction, and all these different motions appear to be going on at the same time. Thus, if a turning spiral pattern be steadily regarded for some minutes, the gaze being directed at the centre, the sense of rotation being such, that from all directions there appears to be a movement of convergence to the centre, on turning the gaze to some other object, that object appears to be enlarging and approaching.

The muscular-slipping theory is therefore out of the question, since the muscles of the eye cannot slip in all directions at once: and if they slipped in any one direction, this would affect objects over all the visual field, not over one region only.

The theory which the author has, however, to propound is virtually a new law of retinal activity. It is as follows: *the retina ceases to perceive as a motion a steady motion of images that pass for some time over a particular region; and to a portion of the retina so affected, a body not in motion appears to be moving in a complementary sense.* It is a law analogous to that of the subjective complementary colours seen after looking at a coloured body. It is analogous to other laws of nerve perception, where we lose consciousness of steady phenomena, and become conscious only of changes. Thus a steady sound of one pitch and intensity ceases to be heard. A steady light of one colour, as gas-light, ceases to be noticed as yellow. A steady taste—as that of garlic pervading every kind of food in some countries, ceases to be perceived until it is perceived by its absence. The same is true of our perceptions of change of temperature. All these laws are probably only different aspects of a much more general law of nervous perception. It is quite consonant with these laws, that when any portion of the retina is affected by an image of objects moving steadily in any direction over it that portion of the retina gradually loses consciousness of the motion, and perceives it only as if at rest. When, however, an object really at rest is looked at, to that portion of the retina thus affected the fixed object appears in motion, but in an opposite direction. To the law expressing this fact the author proposes to give the name of the Law of Subjective Complementary Motion.

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4. *On the Comparative Osteology of the Arm.* *By* Dr. T. P. Durand.

The author, after referring to Martin's theory of the torsion of the humerus, states his belief that in tracing the variations of the forelimb from the amphibia upwards, two groups of animals may be distinguished. In one, including the Cetacea and Aves, the torsion is outwards; in the other, including the Emydæ, most other reptiles, and all terrestrial mammals, the torsion is inwards. The exceptional forms of humerus observed in Monotremata, the Sirenia, Proboscidea, and Pinnepedia are then treated at length. Due weight is given to the action of muscles as a modifying agent in the form of the humerus.

SATURDAY, AUGUST 23.

The Department did not meet.

MONDAY, AUGUST 25.

The Chairman delivered the following Address:—

The Association to which we belong seeks to advance Natural Science, that is to say, accurate knowledge of the material world, by the following means:—

1st.—By bringing together men who are engaged in the various fields of science indicated by our several Sections, by promoting friendship between them, by giving opportunity for discussion on points of difference, by encouraging obscure but genuine labourers with the applause of the leaders whom they have learnt to venerate, and by fostering that feeling of respect for other branches of science, that knowledge of and interest in their progress, which chiefly marks the liberality of scientific study.

Secondly.—The Association provides funds, which, though small in amount, are great in worth, from the mode of their distribution; and serve in a limited degree as an encouragement, though not an endowment, of research. One proof of the value of this method of subsidising unremunerative work by small grants distributed by the master workmen themselves is given by the fact that the sum of 4,000*l.* annually contributed by the Government of the United Kingdom for the endowment of research is distributed on the same plan by a Committee of the Royal Society.

The Third and most important aim of our Association is, 'to obtain a more general attention to the objects and methods of Science, and the removal of any disadvantages of a public kind which impede its progress.' It is for this reason that the Association travels from one to another of the great centres of population and intellectual activity of the kingdom. Local scientific societies and local museums are generated and regenerated in its path, local industries are for a time raised to a higher level than that of money-getting, and every artisan may learn how his own craft depends upon knowledge of the facts of nature, and how he forms part of the great system of applied science which is subduing the earth and all its powers to the use of man. We wish to make science popular, not by deceiving idlers into the belief that any thorough knowledge can be easy, but by exciting interest in its objects and appreciation of its methods. In the popular evening lectures you will hear those who are best qualified to speak upon their several subjects, not preaching with the dry austerity of a pedant, but bringing their own enthusiasm to kindle a contagious fire in those who hear them.

Endeavouring to aid in these objects, I shall in this introductory address offer you some considerations upon the bearing of Biology in general, and Anatomy and Physiology in particular, upon national well-being and public interests.

Biology is the science of the structure, the functions, the distribution, and the succession in time of all living beings. If the proper study of mankind be man, he has learnt late in the inquiry that he can only understand himself by recognising that he is but one of a vast chain of organic creation; that intelligible human anatomy must be based upon comparative anatomy; that human physiology can only be approached as a branch of general physiology, and that even the humblest mould or seaweed may furnish help to explain the most important problems of human existence.

The branch of Physiology which is concerned with man, not as an individual, but a family, the branch which we now call Anthropology, is obviously related to practical Politics, and it was not without reason that the late illustrious pathologist Rokitansky began a speech in the Upper House of the Austrian Parliament on the Autonomy of the Bohemian nation with the words, 'The question really is whether the doctrine of Darwin be true or no.'

In another department, that of Psychology, the physiology of the nervous system has already thrown more light upon the mysterious phenomena of consciousness than was gained by the acutest minds of all ages without the help of anatomical methods.

All the improvements of modern Agriculture and stock-breeding rest upon more or less perfectly understood scientific principles, and the more perfectly the results

have been first worked out in the laboratory the more safe and the more lucrative will be their application in the field.[1]

Still more important is the relation of Physiology to the national Health. The commonplaces of hygiene which are now, one may be thankful to say, taught, if not practised, in almost every schoolroom and factory in England, are the direct results of the abstruse researches of Boyle and Priestley, of Lavoisier and Pasteur Ages of experience did not teach mankind the value of fresh air or the innocence of clean water. Indeed, I have myself heard astonishment expressed by a German professor at the peculiar immunity with which English skins will bear the daily and unstinted application of soap and water.

If the art of keeping a community in health is but the application of plain physiological laws, it is no less true that the art of restoring the health, curative, as distinct from preventive Medicine, rests upon the same basis. In former days the physician was one who recognised what he called the disease of his patient, who referred to his books of precedents as a lawyer to his statutes, and who prescribed a proper remedy to cast out the disease. We now know that dis-ease is, as the name implies, a purely subjective conception. The disease of a host is the health of the parasite, and we cure a human sufferer by poisoning the animals or plants which interfere with his comfort. The same changes which in the old man are the natural steps of decay, the absence of which after a certain age would be truly pathological, are the cause of acute disease in the young. Pathology has no laws distinct from those of Physiology.

When these now obvious considerations are thoroughly understood, it clearly follows that all 'systems of medicine' are in their very nature condemned. All that the art of Medicine can do is to apply a knowledge of natural laws, of mechanics and of hydrostatics, of botany and zoology, of chemistry and electricity, of the behaviour of living cells and organs when subjected to the influence of heat and of cold, of acids and alkalis, of alcohols and ethers, of narcotics and stimulants, so as to modify certain deviations from ordinary structure and function which are productive of pain, or discomfort, or death. It is, therefore, plain that rational medicine, or keeping right and setting right the human body must rest upon a knowledge of its structure and its actions, just as a steam-engine or a watch cannot be mended upon general principles, but only by one who is familiar with their construction and working, and who can detect the source of their irregularity.

An objector may say:—'Admitting that medicine is an art, it is a purely empirical art. You cannot detect the origin of many of the maladies which you are yet able to cure; your best remedies have not been obtained by scientific experiment, but by chance observation and accumulated experience; and if you doctors would give more time to practical therapeutics, that is, to finding out what is good for the several aches and pains we complain of, you would spend your time better than in abstruse researches into microscopic anatomy or the properties of a dead frog's muscle.'

The answer to the objection is an appeal to fact. For centuries, so called observation and experience left medicine in the condition it occupied at the end of the 17th century. The progress of therapeutics is to be marked, not by the labours of 'practical men,' (who, by the way, are of all the most theoretical, only that their theories are wrong), but by the, at first sight, unconnected studies of Descartes and Newton, of Hooke and Grew, of Lavoisier and Davy and Volta, of Marshall Hall and Johannes Müller.

The history of science proves that unconnected, unsystematic, inaccurate observations are worth nothing. For untold ages men have had ample opportunities of studying the indications of the weather, and have felt the utmost desire to obtain a knowledge of what they portend. Yet it may fairly be said that nothing had been done to the purpose, until combined and systematic observations were made in this country and America. The fact is, that popular notions do not rest upon experience or observation. They rest, with scarcely an exception, upon metaphysical theories. In dealing with uneducated persons, both of the lower and higher ranks,

[1] I need only refer to the fruitful labours of Mr. Lawes and Dr. Gilbert in this direction.

physicians find abundance of theories as to the nature and the origin of disease, and of suggestions as to its cure. The only thing which would be of value is what we can scarcely ever get, an accurate observation of what they see and feel. Every fallacy of popular medicine, every solemn medical imposture, is the ghost of some long defunct doctrine of the schools. Therefore, it is that common experience is almost absolutely useless in all practical arts which, without exception, depend for their progress upon the advance of science, that is, upon methodical, continuous and scrupulously accurate observations and experiments.

Many important advances in the practice of medicine have been gained by direct and intentional experiments instituted with a therapeutical object. Such was the Hunterian operation for aneurism, the process of skin-grafting, and subperiosteal operations, such was the administration of chloroform and the introduction of nitrite of amyl, chloral hydrate, and carbolic acid. Such direct experiments still go on, and among them deserve mention for the skill and the untiring patience with which they were carried out, those investigations upon the action of various drugs upon the secretion of bile for which we are indebted to Professor Rutherford and his coadjutors. Even apparently accidental discoveries were not made accidentally. Hundreds of country surgeons must have been familiar with the cow-pox, and have seen examples of the immunity it conferred from the more terrible variola, but he who discovered vaccination was no falsely called practical man. He was a man of science, the friend of Hunter and of Cavendish, an anatomist and natural philosopher. The fruits of Jenner's discovery are spread over the whole earth. This humble village doctor has saved more lives than the most glorious conqueror destroyed, but his name is little honoured, and the only monument to his memory has been banished from association with vulgar kings and skilful homicides to an obscure corner of the great city, where his only homage is the health and beauty of the children who play around his statue.

But after all, it is not so much by direct and immediate contributions to the art of healing that Physiology has vindicated her ancient title of the Institutes of medicine, numerous and important as these contributions have been. It is still more by the scientific spirit which has transformed the empty learning so justly ridiculed by Molière and Le Sage into the practical efficiency of modern surgery. Let me give an instance of what I mean. The notion of measuring the temperature of the body is simple enough, and the rough observation that in inflammation the temperature is raised had led to the various terms by which it was denoted in ancient medicine, and to numberless theories now happily forgotten. But although the thermometer was well known, and had been applied by many scientific physicians, notably by De Haen, by Dr. John Davy, and by Sir Benjamin Brodie, yet the practical value of the clinical thermometer which now every practitioner carries in his pocket was not understood until the other day. Those only who had been trained in accurate physical and physiological investigations, who had learned the worse than uselessness of 'rough observation,' were able to see the enormous importance of clinical thermometry. This most practical of modern improvements in medicine would never have been dreamt of by 'practical men': we owe it to the scientific training of German laboratories.

If Physiology is of such great national importance, if the necessity of experimental research is so vital to the common national wealth, to agriculture and commerce, to health and well-being, ought not its well-ascertained results to be taught in our common schools, and its prosecution directly encouraged by the State?

There is no question of the great importance of children being taught the rudimentary laws of health, the bodily evils of dirt and sloth and vice, the excellence of temperance, the danger of the first inroads of disease. Such teaching now broadcast in many excellent manuals as 'The Personal Care of Health,' by the late Dr. Parkes, and Dr. Bridges' 'Catechism of Health' is no doubt extremely valuable, and happily is daily more and more diffused. But when beyond the direct utility of such knowledge, we attempt to make it an intellectual discipline, there are, I conceive, difficulties which will always prevent even elementary physiology from forming an important part of general education. First, there is the practical

difficulty of the necessary dissections, next the impossibility of making physiology demonstrative, and thirdly, the abstruseness of the subject. It is impossible to have even an elementary knowledge of the laws of living beings without a very considerable familiarity with those of physics and of chemistry, and even in medical schools it requires all our efforts to prevent it degenerating into a mere dogmatic statement of results, or a laboured repetition of hearsay statements. As an intellectual discipline, for facility of demonstration, for the simplicity of the objects, their beauty and interest, their associations with the green lanes and broad moors of England, with the poetry of Cymbeline and Lycidas, with fairy tales and local folk-lore—Botany is to my mind the branch of natural science which is above all others to be chosen where one only can be taught. Next in importance I would place Elementary Physics, the knowledge of the simplest laws of masses at rest and in motion, of heat and light. Its great recommendations are its precision, its constant and useful illustrations in daily life, the interest it gives to the handicrafts and manufactures in which so large a number of English boys and girls are busied, and the necessity of such knowledge as the first step in acquiring all other natural sciences.

First, then, I would that every Sheffield girl should love flowers with the deep and abiding affection of familiar knowledge, and that every Sheffield lad should know every common plant in your beautiful woods and find his purest pleasure on the heights of Bell Hag and the broad expanse of Stanage Edge. And next I would that your workmen and workboys should know so much of mechanics that they may take an intelligent pride in your vast factories, and that in some of them may be awakened the genius to which we trust to repeat in future generations the national services of Arkwright, and Watt, and Stevenson.

With regard to the endowment of research in Biology, I must confess that I should be sorry to see it undertaken by government funds. That such investigations are of public interest, that they are difficult and expensive, and that at present they languish for want of adequate support, is all true. But this country is not so poor, nor our countrymen so wanting in public spirit, that we need appeal to the national purse to supply every ascertained want. Great as is the national importance of science, the nation is more important still; and even if that were the alternative, I would rather that we should indefinitely be dependent on Germany for our knowledge than give up the local energy, the unofficial zeal which has made England what she is. Far better for the strength and the civilization of the nation that a thousand pounds were raised every year for the endowment of unremunerative researches in this wealthy town of Sheffield, than that ten thousand were paid you by a paternal monarch or an enlightened department.

But surely there is no need for us to go to Parliament for such sums as we require. In the first place, scientific men themselves show a good example of not asking before they give. There is the modest sum which we raise in this Association, there are the funds for helping research of the Royal Society, the Chemical Society, the British Medical Association, the Iron and Steel Institute, the Whitworth Scholarships. Next we have the resources of our Universities, which have scarcely begun to apply themselves to the task. I need do no more than allude to the Cavendish Laboratory, or to the Physiological School, at Cambridge, where a simple College tutor, of rare ability, and of still more rare sympathy and energy, has, in ten years, achieved results which we need not shrink from comparing with those of the great continental laboratories. The magnificent Museum of Anatomy, maintained by the College of Surgeons almost entirely out of their own funds, is another instance of private care for science to which we find no parallel abroad; and the Zoological Society wisely spends a large part of its income in prosecuting Comparative Anatomy, and publishing its beautifully illustrated Memoirs.

But beside the efforts of scientific bodies and the wealth of our national Universities, we may surely look to the public spirit of ancient companies and corporations to do something for the cause of science. In the middle ages our country was covered with parish churches by private munificence: in the sixteenth century most of our public and grammar schools were endowed; in later times our great religious and charitable societies were founded. May we not hope that,

before the close of the present century, the discriminating knowledge which alone prevents gifts of money from being a curse instead of a blessing to a community, may lead to the establishment of libraries, and museums, and laboratories by universities and towns, which shall bear comparison, I will not say with those of Paris, or Leipzic, or Bonn, but with the poorer but scarcely less distinguished schools of Heidelburg and Göttingen, of Würzberg and of Utrecht?

Here and there we have institutions already under Government control and patronage. Let them be maintained as efficiently and liberally as possible. The British Museum and its Library, the Royal Observatory at Greenwich, and the Royal Gardens at Kew (happily preserved for the present from the short-sighted eagerness of those who would destroy their scientific value), these are great national institutions of which we are justly proud. Successive Governments will have enough to do to maintain their efficiency and to guard them from incompetent interference.

Whatever may be thought of the duty of the State directly to encourage the pursuit of Animal and Vegetable Physiology, one would have supposed that at least what diplomatists call a benevolent neutrality would be shown to a pursuit so laborious and costly, which demands trained workmen and the devotion of a life-time, which is so important for the national wealth and health, and which, by reason, by experience, and by testimony, we know to be the only guarantee for advance in the various branches of the healing art. Why is it then that institutions which owe nothing to government assistance, and men who spend their time and talents in self-denying and unremunerative service for the public good, are not suffered to pursue their beneficent work in peace? You know that certain persons who profess to be shocked by the methods of physiological research have succeeded in placing this branch of science under as great disabilities as that sense of humour would allow which so often redeems British ignorance from its most mischievous results.

The method that has given rise to so much excitement is the performance of experiments upon living animals. Now, if this were injurious to the greatest good of the greatest number of the community, or if freedom to perform these experiments interfered with the freedom of other persons to abstain from them, or if such experiments were forbidden by any religious or moral authority, by the Ten Commandments or by Mr. Matthew Arnold, of course they must be given up; but equally, of course, the science of Physiology must also come to a stop, and the farmer, the cattle-breeder, and the physician must be content with such knowledge or such ignorance as he at present possesses. I know it has been asserted that the science of the functions of living organs is quite independent of experiment upon living organs. But this is said by the same persons who have denied that the art of setting right the functions of the body when they go wrong has anything to do with the knowledge of what those functions are.

If you could be persuaded that Chemistry can make progress without retorts and balances, that a geologist's hammer is a useless incumbrance, or that engineers can build bridges just as well by the rule of thumb as by the knowledge gained in a workshop, then you might believe that Physiology also is independent of experiment.

It is absurd to object to the difficulties of the research or even the contradictory results sometimes obtained. The functions of a muscle or a gland are more complicated than those of water or gas, and their investigation needs greater skill, more caution, and more frequent repetition. Imperfect experiments can lead to nothing but error; criticism from other physiologists, or from scientific men experienced in other branches of research, is not wanting and is always valuable. But vague assertion that further progress is impossible by the very means which have led to all our present knowledge, coming from those 'who are not of our school'—or any school, is undeserving of serious notice.

The real contention of course is a moral one, that we ought to relinquish the advantage of all experiments which are accompanied with pain to the creature experimented on. The botanist may serve his plants as he pleases, and even the animal physiologist may cut, or starve, or poison all sentient organisms which happen not to possess a backbone, and he may try experiments with all backboned

animals, including himself and his friends, so long as they do not hurt, but that must be the limit. On the most extreme humanitarian views no objection can be made to experiments upon animals in a state of insensibility to pain, and as these constitute, happily, the vast majority of physiological experiments, the question is narrowed to comparatively restricted limits. Is it wrong to inflict painful experiments upon animals for the sake of Science? In the absence of any authority to appeal to, we can but judge of the matter by analogy. Now it has been the practice of all mankind, and is still allowed by the common consent both of law and feeling, that we should destroy by more or less painful means, that we should enslave and force to work, and mutilate by painful operations, and hunt to death, and wound, and lacerate, and torture the brute creation for the following objects:—for our own self-preservation, as when we offer a reward for the killing of tigers and snakes in India; for our comfort, as when we poison or otherwise destroy internal parasites, and vermin, and rats, and rabbits. Our safety, our food, our convenience, our wealth, or our amusement: all these objects have been and are regarded by the great mass of mankind, and are held by the laws of every civilised country to be sufficiently important to justify the infliction of pain or death upon animals in whatever numbers may be necessary. The only restriction which Christian morality or in certain cases recent legislation imposes upon such practices is, that no more pain shall be inflicted than is necessary for the object in view. Killing or hurting domestic animals when moved by passion or by the horrible delight which some depraved natures feel in the act of inflicting pain was until lately the only recognised transgression against the law of England. I trust I need not say that it is only under such restrictions that physiologists desire to work.[1] Anyone who would inflict a single pang beyond what is necessary for a scientific object, or would by carelessness fail to take due care of the animals he has to deal with, would be justly amenable to public reprobation. And, remember it is within these limits that the whole controversy lies, for after a long and patient examination of all that could be said by our accusers, the Royal Commission which was nominated for the purpose unanimously reported that in this country at least scientific experiments upon animals are free from abuse.

What is deliberately asserted is that within the restrictions which all humane persons impose upon themselves, it is lawful to inflict pain or death upon animals for profit or for sport, for money or for pastime; that property and sport are in England sacred things; but that the practices which they justify are unjustifiable when pursued with the object of increasing human knowledge or of relieving human suffering.

Of those persons who answer that they consider vivisection for the sake of sport to be almost as detestable as vivisection for the sake of duty, I would only ask first that they should deal impartially with both offences; and secondly, that since in the one case their opinions are opposed to the practice of genteel society, and in the other to the convictions of all who are qualified to judge, they should at least contemplate the possibility of being mistaken. Putting the question of field sports altogether aside, you know perfectly well that in every village in England an extremely painful mutilation is constantly performed upon domestic animals in no registered laboratory, under no anæsthetics, and with no object but the convenience and profit of the owner. You remember how when an epidemic threatened the destruction of valuable property, every booby peer now eager to stop, so far as in him lies, the advance of knowledge, was no less eager to have carried out at the public expense any slaughter and any experiments, painful or otherwise, which would save his pocket.

But you will say: all this seems reasonable enough; but if so, how do you account for the prejudice against you, what has induced so many amiable and otherwise sane persons to join in the outcry against Physiology?

First, I answer, it is due to the most frequent cause of folly—Ignorance. Many

[1] They are, in fact, the very limits that were put on record by this Association long before the agitation against Physiology began. See Report for 1871, p. 144.

persons supposed to be educated are so destitute of the most ordinary conceptions of natural science that they do not understand the necessity for experiments. So little do they appreciate the difference between formal knowledge and real knowledge, that a distinguished statesman once assured me that he would as soon have his leg set by a man who had gained what he called his knowledge from books, as by one who had 'walked the hospitals.' Next, there is the vulgar dislike of whatever is not obviously and immediately useful. When knowledge for its own sake is in question, those of the baser sort are always ready to cry with equal ignorance of literature and of science, *Cui bono?*

In another class of persons, less ignorant and less stupid than these two, opposition to physiological experiments appears to spring from what may fairly be stigmatised as Sentiment, that is to say, excitable, rather than deep feeling, uncontrolled by reason. People first gratify their fancy by calling cats and dogs our fellow creatures, which, in one sense, undoubtedly they are, and then, by the familiar fallacy of an ambiguous middle term, argue that it is cruel to put our fellow creatures to pain; or, as some would add, to reduce them to slavery, or to use them in any way for our own, rather than their good. Such persons compel their fellow creatures to drag them through the streets, they eat their fellow creatures when sufficiently vivisected to be palatable, and they find philosophical excuses for those who kill their fellow creatures for fun. But they are properly shocked when their fellow creatures are hurt or killed for the benefit of mankind. Such persons have been accused of feminine weakness; but I must say that I have never found an intelligent woman who could not see the rights of the case when fairly explained to her, whereas I have met a few men who on this, as in other matters, consistently refuse to give up to argument the notions which were formed by prejudice.

This sentiment is, I admit, the degradation of just feeling. To many unaffectedly compassionate hearts there is a peculiar pang in thinking of suffering which is deliberately inflicted, with only the justification of duty, instead of the excuse of ignorance or passion. They see in the helplessness of the dumb animals an appeal for pity, almost like that of childhood, and are justly indignant with the selfish cruelty so often exercised upon them. All honour to the efforts which have banished so many cruel sports from England; all honour to the Society which seeks to prevent cruelty to animals. If it can point to any additional means by which the sufferings of animals in the cause of Science can be diminished, we shall be anxious to adopt them. If it can point to any abuse in one of our laboratories, we will hasten to correct it. This Society has honourably declared that they know of none. That physiologists have been heedless, or even callous, in their experiments upon animals in past times, when men were strangely insensible even to human suffering, or in countries where a healthy result of Christian civilisation has not yet been seen in habitual gentleness to animals, I need not deny. Such cases have been eagerly sought and sometimes most unfairly judged. Only lately a learned body felt itself not strong enough to retain the admittedly invaluable services of an eminent foreigner who had once admitted that when absorbed in scientific and beneficent researches he lost sight of any pain that might be inflicted.[1] Is not this the very excuse which is held valid in the case of sport? Doubtless we ought to be ever mindful of every branch of duty, but such occasional forgetfulness does not show hardness of heart. It is an excusable weakness for a student of medicine to shudder or to faint at the sight of blood, but he learns that this merely physical sensibility becomes selfish and mischievous if indulged: he is taught to suppress all such exhibition of emotion, and to let it stimulate without interfering with his efforts to relieve. But no one surely would think the hysterical youth more truly humane than the surgeon whose compassion is shown in the very firmness with which he inflicts a temporary pain for an ultimate good.

[1] Fortunately, Dr. Klein, whose researches in microscopic anatomy and pathology are so well known and appreciated, knows that he retains the confidence and respect of his scientific brethren, and we hope that his honourable connection with the largest school of medicine in London will strengthen other and closer ties in binding him to England.

I have hitherto rested the whole argument upon the lawfulness of inflicting pain and death upon the lower animals for the sake of science and humanity, but as a matter of fact I may again assure those who, while assenting to the justice of the plea, yet shrink from what it may involve, that the great majority of experiments upon animals are rendered painless, and that the remainder are mostly those experiments which are most immediately and directly subservient to medical art, and which happily are generally productive rather of discomfort than of pain. Let me give you an example of such a vivisection, far more painful than the immense majority of those of the laboratory. Suppose a country surgeon were sent for late at night to some case of urgent peril; knowing that his ride is for life or death, and unsparing of himself or his horse, he rides him to the utmost limits of endurance, and beyond: who would not applaud the action? Those only who appear deliberately to believe that our life is worth less than that of many sparrows, those legislators only who look forward to the time when wars will cease, not because of human slaughter, of devastated homes, of all the horrors which the world has endured for centuries, but because of the cruelties to which the horses in the artillery are subjected. We, who are familiar with human suffering and sorrow, which our knowledge is all too feeble to prevent, best understand how in testing some new remedy on a less precious fellow-creature than a man, one who is truly humane may be tempted to forget the comparatively trivial suffering of a rabbit or a frog.

But some enthusiastic opponent will say, 'I cannot pretend to doubt that these experiments are in every sense of the word useful, but we ought not to purchase the benefit they confer by inflicting pain upon innocent creatures. I would sign a petition to-morrow to put down all field sports by law, I would allow no operation upon domestic animals, and I will abstain from all animal food until I am certain that I can eat creatures which have been killed without suffering pain. But if I were lying at the point of death, and you brought an animal to my bedside and assured me that by putting it to pain my life could be saved, I would refuse to purchase it on such cruel terms.' We may hope that the excellent person who made this heroic profession would in the hour of trial be better advised, but if not we may surely reply, 'Right reverend sir, you are the best judge of the value of your own life, and if you think proper to sacrifice it to the comfort of a guinea-pig we must submit to the loss with such resignation as we can muster; but when you say that in obedience to this silly whim you will let your dearest friend suffer, allow the sacrifice of the most important life, and forbid those studies which have already rescued multitudes from deformity and misery and death, then those of us who have to do with the real responsibilities of life, and on whom presses the awful sense of impotence to which our defective science too often leaves us, answer that we too have duties to fulfil, and to the best of our power we mean conscientiously to fulfil them.

There is, I fear, another reason which animates much of the opposition to physiological experiments. It is nothing else than aversion from the methods and the results of science. It may be that an excuse for this dislike has been furnished by the pretence of false science, and the arrogance of much even which is true. But surely, no reasonable creature, from such trivial irritation, can deliberately wish to check the progress of accurate knowledge by observation and experiment. There are, indeed, some who, fearing (as I think prudently) that, while a little knowledge inclineth men to Atheism, greater knowledge turneth them round again to religion, and desiring to subject the human mind to a bondage as hard and more degrading than that of mediæval Rome, would gladly call off interest from the unremunerative labours which are prompted only by the thirst for knowledge and faith in the possibility of learning more and more of the divine order of the world, to pursuits which bring obvious and material utility. There are those again, who, fearing (as I think foolishly) that increasing knowledge of this Divine order will lower our admiration of its beauty, or that the better a man understands the laws of God the more likely he is to break them, have an unfeigned dislike for natural science in general, and for Biology in particular. They repeat over again the error of which the Dominican friars with far greater excuse were guilty when they imprisoned Galileo. If any such are here, may I venture to tell them—in quietness

and in confidence is your strength: the vast fabric of Christian morals is in no danger of being overturned by the discovery of a new chemical method in the laboratory, or of a hitherto undescribed animalcule. If noisy attacks are made in the injured name of science, you have only to wait, and you will see these attacks repelled by the true leaders of science themselves, or, at the worst, by the next generation. But if, leaving your secure fortress of defence, you come down with your rhetoric and your sentiments, your *petitio principii*, your *ignoratio elenchi*, and all your familiar fallacies and tropes, thinking that with such weapons you can meet on their own ground men who have spent their lives in the study of science, then no wonder if you suffer grievous defeat. Happy for you if you learn, like another discomfited pilgrim, to betake yourselves to another 'weapon.'

But I imagine that some of my audience are saying: 'This defence would have been necessary before the Royal Commission made their report; but when that was made, and affirmed the necessity of physiological experiments, and the groundlessness of accusations of cruelty against physiologists, when an Act was passed which licenses physiological laboratories, under the very restrictions which you had already imposed upon yourselves, may we not regard the controversy as closed, and the result as satisfactory?'

I answer that I have taken up your time with this defence of physiological experiments partly because I would fain help, however feebly, in the enlightenment of the public conscience, but also because the result of recent legislation is *not* satisfactory.

Science does not work readily in fetters. A system of licenses and certificates, numerous and complicated, obtained with trouble and delay, and revocable at the will of a Minister who may, by the accidents of party, be at any time amenable to anti-scientific influences, such a system adds serious difficulties to those already in the way of experiments.

Suppose, as an illustration, that certain persons opposed on various grounds to learning, and especially hostile to Greek, had attacked the study of Plato. They would point out the danger of modern ladies becoming as well read in his writings as was Lady Jane Grey. They would show that the laxity of modern manners was coincident with the popularity of the *Symposium*, and that the notorious increase of infanticide was the result of the teaching of the *Republic*. Associations for the total suppression of Plato would be formed, with hired advocates, and anonymous letters, and 'leaflets,' spreading a knowledge of his most objectionable passages. Scholars would be threatened with eternal punishment, and schoolmasters with the withdrawal of their pupils. Then a Royal Commission would be appointed—a great Latin scholar, a Whig and a Tory statesman (who, having taken a B. Sc. degree at Oxford, would be impartially ignorant of Greek), the most intelligent despiser of Plato who could be found, the master of a grammar school on the modern side, and (perhaps the most efficient of all) a lawyer, who knew nothing about Greek but hated cant. This Commission would take evidence that the Platonic writings were not all immoral, that they had been quoted with approval by Fathers of the Church, that they were of great importance to literature and philosophy, and even to the elucidation of the Sacred Writings. It would also be proved that the Platonic Dialogues were far less immoral than multitudes of other widely circulated books, and even than a French novel which one of the Royal Commissioners happened to be reading, and, lastly, that the morals of Greek scholars, and of clergymen who had read Plato at college, were not obviously degraded below those of other people. On the other hand, witnesses would depose that a knowledge of Plato was of no consequence to a student of philosophy; that if it were, the text was in so corrupt a condition that no two scholars agreed as to a single chapter; and that, after all, philosophy was of no practical use, least of all to clergymen. Others would affirm that though they had never read a line of him, they knew that his style was as vicious as his sentiments; and perhaps some cross-grained scholar might be found who, having once edited a Greek play, would declare that all studies in Greek literature ought to be restricted to the tragedians, and that for his part he had never opened any other authors and had never felt the want of them.

At last the Commission would report that there was no question of the value

of the works of Plato, that it would be mischievous and impracticable to prohibit their study, and that there was no evidence that schoolmasters habitually chose the least edifying passages as lessons for boys. Then what is called a compromise would be made. It would be enacted that Plato might be read, but only in colleges annually licensed for that purpose; that everyone wishing to read must have a general certificate signed by certain professors, and setting forth his object, also to be renewed every year; and that special certificates might be severally obtained for reading certain excepted dialogues, for copying from them, for publishing them, or, in rare cases, for translating them.

However reasonably such a system might be administered, who can doubt that the result would be a diminution of the number of scholars, and a check to the progress of learning?

Now this is what legislation has done for physiological experiments. The Act 39 & 40 Victoriæ was hastily drawn and hurriedly discussed; for noble lords and honourable gentlemen who had been taught from childhood to vivisect for unscientific purposes were eager to hurry off to their own merry vivisections, for which they were ready provided with license and certificates. And it works as might be expected. Some shrink from seeing their names figure in disreputable newspapers, and receiving more or less savagely abusive anonymous letters. Others have no laboratories, and find difficulty in licensing their houses. Others are refused the certificates they require.

In one case two thoroughly qualified men were anxious to carry out an important investigation on the treatment of snake-bites. They procured venomous snakes from a distance, and applied for the special certificates necessary. Considerable delay ensued; various objections were raised, and set at rest; and at last all the certificates were obtained; but meantime the snakes had died.

I must apologise for having detained you so long. The whole history of this controversy is melancholy but instructive.

To those of my audience who wish well to Science, I hope that I may have made more clear the grounds on which vivisection is necessary and right, and thus fulfilled one of the chief objects of the Association—'to obtain the removal of any disadvantage of a public kind which impedes the progress of science.'

To those working physiologists who have honoured me by their presence I would express the assurance that they have the confidence and the gratitude of the medical profession, witnesses at once competent and impartial, who know the difficulties and the value of such labours; and as to present discouragements, looking back to the obstacles which so long retarded the progress of our kindred science, Anatomy, I may say

O passi graviora, dabit Deus his quoque finem.

When, in the earliest years of the Royal Society, Sir Christopher Wren and Dr. Lower made those experiments on transfusion of blood which have at last proved so beneficent, there were not wanting shallow witlings who scoffed at their researches. It was of them that Cowley wrote with a just indignation—

Whoever would deposed Truth advance
Into the throne usurped from it,
Must feel at first the blows of ignorance
And the sharp points of envious wit.

You have at least escaped the latter penalty.

Dishonour fall on those
Who would to laughter or to scorn expose
So virtuous and so noble a design,
So human for its use, for knowledge so divine!

You wish your culminators no greater dishonour than failure to do mischief. You wish for yourselves no other reward than 'the wages of going on.'

The following Papers were read :—

1. *Experiments on Septic Organisms in Living Tissues.* *By* Staff-Surgeon Edward L. Moss, *R.N.*

In 1874 some attempts to preserve meat in a state fit for dietetic purposes, and apparently some suggestion from the eminent German, Surgeon Bilroth, induced Professor Tiegel to undertake a series of experiments with the intention of deciding whether septic organisms exist in the living tissues.

With this object Dr. Teigel sealed up various parts of the bodies of newly-slain rabbits by dropping them into melted paraffin at a temperature assumed to be high enough to destroy any infection they might receive in transit from the animal's body to the dish of paraffin. He found that, in most instances, the unheated centre of his lumps of flesh became in a few days putrid and swarming with bacteria.[1]

This result was so striking that his experiments were repeated by Dr. Burdon Sanderson,[2] with the only difference that the red kernel of uncooked tissue *always* contained bacteria, whereas Teigel's results were not so uniform, as may be seen by his reply to Professor Klebs in a number of Virchow's 'Archives' following the paper summing up his experiments.

On the other hand, Messrs. Chiene and Cossar Ewart reached a very different conclusion after a course of similar experiments, in which, however, they laid special stress on the use of an additional precaution in the shape of antiseptic spray.[3] But the action of a bactericide cannot be limited to defence only, and their experiments would have been more convincing if the pieces of meat had not been exposed to an agent capable of penetrating the flesh and killing or arresting the growth of any bacteria it may have contained. If, however, meat sealed in air pure and simple will remain unputrefied, it is fair to conclude that the fragments so remaining are free from the special organisms that cause putrefaction.

In the winter of 1875, I sealed up a piece of musk-ox meat in clean Arctic air, and it remained perfectly fresh until the glass tube containing it was accidentally broken thirteen months afterward. In this case any sources of putrefaction which may have existed in the flesh were possibly destroyed by the low temperature to which it had been exposed. On looking up what had been written on the subject I found the accounts of the experiments just referred to, and it appeared worth while to try whether flesh would keep equally well if removed warm from the body of a recently killed animal and simply sealed in an atmosphere whose freedom from life could be guaranteed.

Availing myself of the facilities afforded by the laboratory of the Royal Dublin Society, I led a pipe from the nozzle of a well-weighted blacksmith's bellows, through a tube of hard glass six feet long well packed with platinum foil, and heated to redness in a Hoffmann combustion furnace. I thus obtained a stream of air at the rate of 70 cubic feet an hour at a temperature which quickly singed cotton-wool, and varied during the operation between 380° and 420° Fahr., as was shown by a thermometer let into the outflowing end of the tube—a brass pipe, first thoroughly cleansed by heating to redness, was surrounded by a freezing mixture and served to cool the current to a temperature between 70° and 80°.

In the air thus obtained I removed pieces of flesh from the dorsal muscles of a decapitated rabbit—using a scorched knife and forceps—and sealed them in glass tubes cleaned by heating to redness, and through which a current of the sterilised air was kept flowing until the fragments were put in. In order to close the tubes, the wider end of each was first stopped with well-baked cotton wool, the narrower end then fused off from the branch-pipe conveying the current, and, finally, the space of tube between the stopper of cotton wool and the flesh was fused, drawn out, and closed.

Three tubes containing muscle, and one with brain, were thus hermetically

[1] *Virchow's Archives*, vol. 16, p. 453.
[2] *British Medical Journal*, January 1878.
[3] *Journal of Anatomy and Physiology*, April 1878.

sealed, and two others, each containing muscles, were (being found rather too short) left closed with cotton-wool only, which, for security sake, was afterwards covered with a cap of resin and wax cement.

The tubes were filled and sealed on September 2, 1878, and left in a temperature averaging 60° Fahr. On the 9th, tubes Nos. 1, 2, 3, and 4, containing muscle, showed minute hairs of mycelium projecting in one or two places from the flesh. In Nos. 1, 2, and 3 the mycelium never fruited, but disappeared with an increase of the moisture of the flesh. In No. 4—which was one of those stopped with wool only—it fruited into a yellow-headed mucor and then disappeared in a softening débris of evidently putrid flesh. I opened the tube, its contents were fœtid and held myriads of active bacteria, large and small.

The brain remained quite unchanged for ten days, and then suddenly softened and broke down, thus leaving but one of my six specimens intact. On my return home, a few days ago, I found this one altogether unchanged, and I embrace this opportunity of exhibiting it, a piece of muscle which appeared to have neither held or received infection.

Although Nos. 1, 2, and 3 developed mycelium and extruded a quantity of slightly glairy fluid almost equal in bulk to the flesh, it is remarkable that they did not become putrid. I opened one of them three days ago; it had an odour like boiled rabbit and catchup, and was most decidedly not offensive. It, like the others, was speckled over with white aggregations, which I at first thought were fungoid, but on examination found to be bunches of acicular crystals entirely organic. They are insoluble in alcohol or ether, like creatin, but only slightly soluble in warm water. They dissolve in sulphuric acid without blackening. I had not enough of them to examine further. I could not find any bacteria in the fluid, and it was decidedly free from any in an active condition.

The apparatus not being portable, circumstances rendered it impossible for me to continue experiments on flesh; but I endeavoured to follow up the subject of septic organisms in living tissues by observations on blood removed from human veins, by a method which appears to exclude possibility of infection, and at the same time allows the blood to be examined at different intervals, so that germs, if any exist in it, may be cultivated and studied with convenience.

The apparatus consists of a series of small glass bulbs connected by capillary tubes, so that one bulb and its contents can be separated from the rest by fusing and drawing out the connecting tube in the flame of a blowpipe.

The tubes and bulbs are bent on each other, so that the whole series can be readily baked in a water or paraffin bath. One end of the series is left open, packed with baked wool, and connected with an aspirator. The other is drawn to a fine point and sealed. Then the sealed point is enclosed and secured in a short piece of stout indiarubber connection-pipe, which, in its turn, is fastened over the collar of a fine hypodermic needle, protected ready for use in a calcined glass sheath.

When connected, the whole arrangement is baked repeatedly in a water-bath at intervals of four hours. (Mr. Dallinger's septic organism required $5\frac{1}{4}$ hours for its life cycle. Cossar Ewart's bacillus anthracis produced spores in 24 hours.) The apparatus is then ready for use. The mode of procedure is as follows:—The sheath is removed from the needle, and the latter is plunged into any suitable vein —the radial is a convenient one. The sealed point inside the rubber connection tube is broken, and blood flows gently through the series of bulbs drawn on by the aspirator acting through the cotton plug. When sufficient has entered, the flame of a blow-pipe severs the capillary tube next the needle, and instantly afterwards the similar tube next the wool plug.

The apparatus is easily used. I have repeatedly obtained blood from my own arm without assistance. No inconvenience follows the puncture of the vein if the needle is kept steady and a little care exercised to prevent extravasation.

By adopting this method I have constantly, after the lapse of 48 or more hours, found organisms in the blood of intermittent fever which I was altogether unable to find in the fresh blood. They consist of bacterine pairs or single individuals in active locomotion, sometimes stationary in zooglea groups, and occasionally in chains of four or more. The ghost cells recently described at the meeting

of the British Medical Association in Cork, are also to be demonstrated by this method in blood a month sealed.

I have as yet not had sufficient opportunities of experimenting with blood absolutely free from possibility of malarial infection to speak with certainty about the development of organisms in healthy blood; but so far as my experience goes the appearance after a few days of bacterial bodies with more than Brownian motion, which most decidedly do not exist in fresh blood, is the rule rather than the exception.

I have not, however, found any samples of blood subject to a definite spontaneous putrescence. The only change apparent is that the serum, at first of a faint greenish tinge and opaline, becomes more transparent and acquires a crimson colour.

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2. *On the Stroma of Mammalian Red Blood Corpuscles.*
By L. C. Wooldridge, *B.Sc. Lond.*

A new method of preparing stroma by means of dilute sulphuric acid was described, the advantages of which were, that it gave a stroma retaining perfectly the shape of the original corpuscle, and that it was a very expeditious method.

The Stroma itself consists of—

1. Globulin.
2. An albumin, probably alkali albumin.
3. An albuminoid body, containing phosphorus; soluble in dilute soda, insoluble in dilute acid, and insoluble by digestion with artificial gastric.
4. A crystalline body, extracted by ether, which is not fat or cholesterin, nor does it contain any phosphorus; its other properties have not yet been investigated.

The research was mostly carried out under the supervision of Prof. Drechsel, in Prof. Ludwig's Laboratory, at Leipzig.

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3. *Note on Crystallisation of Urea in presence of a Colloid.*
By Dr. W. M. Ord.

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4. *The Nervous System of* Comatula. *By* P. Herbert Carpenter, *M.A.*

Although there is a close histological resemblance between the ambulacral nerves of the starfishes and Crinoids, there is one important point of difference between them. The ambulacral nerves of the starfishes, at any rate of the Ophiurids, send off branches to the muscular bundles which connect successive joints of the rays, and effect the movements of the animal. The swimming movements of *Comatula* are far more active than the movements of any starfish, and are also performed with a singular regularity, while they are effected by the combined contraction of several hundred pairs of muscles; but no branches are traceable from the ambulacral nerves on to these muscles, such as are known in the Ophiurids.

Dr. Carpenter's experiments at Naples have shown that these muscles are under the influence of a governing centre which not only regulates their contractions, but co-ordinates these contractions in the most remarkable manner; and that this centre is situated in the fibrillar envelope of the chambered organ, while the axial cords of the rays and arms are the channels by which the influence of the centre is communicated to the muscles.

This experimental evidence as to the nervous nature of the axial cords is further supported by the results of anatomical investigation. Sections show that these axial cords give off branches regularly in the centre of each segment of the arms and pinnules; and that while some of them ramify upon the ends of the muscular bundles, others are traceable into the small marginal leaflets bordering the ambulacral grooves, where they break up very minutely and become lost. It has also been discovered that in many tropical *Comatulæ*, which have an excentric mouth,

more or fewer, sometimes even more than half of the arms, which come off from the aboral side of the disc, have no ambulacral nerve at all, although the dorsal axial cord gives off its two pairs of branches in the usual way. In one large species from the Philippines, with nearly 200 arms, this condition is not limited to the aboral arms only, but occurs on some of the arms on each radius, while the others have the usual groove and subjacent ambulacral nerve.

These facts are strongly indicative of the nervous nature of the axial cords, although Claus and Gegenbaur in their recently published text-books make no mention of this view at all, and describe the nervous system of *Comatula* as essentially similar to that of the starfishes. It would seem, however, that while the ambulacral nerve of the Ophiurids supplies the muscles as well as the tentacles, these functions are more differentiated in the far more active Crinoids. The axial cords of this group appear to be the principal motor nerves as far as the skeleton is concerned, while the ambulacral nerves supply the tentacles only, possibly having some influence on the slow creeping movements which the isolated disc has been observed to perform. Why should we deny the nervous nature of the axial cords, simply because our doing so would clash with our preconceived notions as to what the Crinoids ought to be, in order to agree with the views on Echinoderm morphology which were adopted without a sufficient knowledge of the anatomy of this most interesting group?

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5. *On a Visual Phenomenon and its Explanation.*

By WILLIAM ACKROYD, *F.I.C.*

Visual phenomena are of general interest, and have been noticed by Brewster, Herschel, and others. The following is the visual phenomenon in question: a globule of water is made to impinge on the cornea, whilst the gaze is unwinkingly fixed on a distant light. Directly after the impact the light appears to be surrounded by a luminous ring, which gradually contracts in diameter. Explanation: A minute ripple is produced on the surface of the cornea. The crested wave-ring and the refracting media of the eye produce two hollow cones of light within the vitreous humour, one with a circular portion of the crystalline lens as base, and the other with the retina as base. As the ripple increases in diameter, the first cone increases in size, and its prolongation (the second cone) diminishes, and its base (in other words, the visible luminous ring), becomes less and less, until it merges into the lamp-light itself.

TUESDAY, AUGUST 26.

The Department did not meet.

SECTION E.—GEOGRAPHY.

PRESIDENT OF THE SECTION—CLEMENTS R. MARKHAM, Esq., C.B., F R S., F.L.S., Sec. R G.S., F.S.A.

THURSDAY, AUGUST 21, 1879.

The PRESIDENT delivered the following Address:—

PART I.

I propose to open the proceedings of this Section by attempting to place in a clear light the objects and aims of geographers, and the position which their science holds relatively with reference to the other sciences, and positively as a distinct body of knowledge with defined limits.

Geography is a knowledge of the earth as it is, and of the changes which have taken place on its surface during historical times. These changes explain to us the laws according to which similar changes are now taking place around us. The subject may be considered from various points of view; but my present endeavour will be to introduce to you, through the remarks I propose to make, the papers that will come before you to-day and at our subsequent meetings. I shall try to do this by explaining the practical uses of geographical knowledge, and its importance to usi n almost every occupation in which we may be engaged.

Our first work as geographers is to measure all parts of earth and sea, to ascertain the relative positions of all places upon the surface of the globe, and to delineate the varied features of that surface. This great work has been proceeding from the first dawn of civilisation, and it will probably be centuries longer before it is completed. Geographers and explorers, surveyors and geodesists, of each generation, work their allotted time, gradually increasing the stock of human knowledge, by enabling other sciences and other branches of inquiry to make parallel advances. For they are all dependent on the accurate measurement and mapping of the earth. Locality is the one basis upon which all human knowledge must rest. Arts, sciences, administration, commerce, depend upon accurate geographical knowledge; and as that knowledge becomes more extensive and more exact, so will every other human pursuit gain increasing light and truthfulness.

We are still very far indeed from an accurate scientific geographical knowledge of even the most civilised countries, while by far the largest portion of the earth's surface is inadequately surveyed, and a smaller, though far from inconsiderable, part is unsurveyed or entirely unknown. In the division of labour, the geodesist produces the accurate large-scale maps which are necessary in thickly populated countries, the topographical surveyor furnishes less exact maps of more thinly peopled and less civilised regions, while the trained explorer forces his way into the unknown parts of the earth.

From the labours of these three classes of workers we, in this generation, and our descendants for many generations to come, must be content to derive our knowledge; but in the fullness of time the whole earth will be measured and delineated as Hallamshire is now. It is to the furthering of this great work that the geographers of each age devote their energies, and its advancement will

increase in rapidity, because, as men become better instructed, there will be more geographers.

The construction of large scale maps on rigorously accurate principles has as yet made inconsiderable progress. It is only in the countries of Europe, in India, and some of our colonies, and in the United States that it has been commenced. But it is very far from being completed anywhere, and the people of Sheffield have had this fact brought home to them within the last year; for the Memoir on the Yorkshire Coal Field, published by the Geological Survey in 1878, was obliged to stop short with the limits of the county, an artificial and inconvenient line which leaves the southern portion of the field undescribed, entirely because the six-inch survey had not yet been extended over Nottinghamshire and Derbyshire. This circumstance strikes us in two ways. It reminds us that geographical work is far from being completed even in the most populous and civilised parts of our own country; and it also brings the fact home to us that the progress of other sciences is dependent upon the advance of geography.

Where the trigonometrical surveys have not been commenced, we have only those maps which are based on positions fixed by astronomical observations, on cross-bearings and chained distances, and which I call (to distinguish them from the results of trigonometrical surveys) the topographical maps. One of the oldest and most interesting of these maps is the famous atlas of the Chinese Empire constructed by the Jesuits between 1708 and 1718. But we are also dependent on such maps for our geographical knowledge of all Asia except India and Palestine, of the Eastern Archipelago, of all Africa and South America, and of the greater part of North America.

Accurate maps are the basis of all inquiry conducted on scientific principles. Without them a geological survey is impossible; nor can botany, zoology, or ethnology be viewed in their broader aspects, unless considerations of locality, altitude, and latitude are kept in view. Not only as the basis of scientific inquiry, but also for the comprehension of history, for operations of war, for administrative purposes, and for the illustration of statistics, the uses of accurate maps are almost infinite. M. Quetelet, in one of his well-known letters, declared that such graphic illustration often afforded immediate conviction of a point which the most subtle mind would find it difficult to perceive without such aid. Maps both generalise and allow of abstraction. They enable inquirers at once to detect and often to rectify errors, which, if undetected, would affect results and throw calculations into confusion. As an example of the use of maps for administrative purposes, the series constructed by Mr. Edward A. Prinsep in India is worthy of notice. They showed the agricultural tribes of a special district arranged according to occupancy of land, political and fiscal divisions, physical features and zones of fertility, productive power as influenced by rain or aided by irrigation, different kinds of soils, acres under different kinds of produce, and lines of traffic. Another most instructive series displays the State irrigation canals acting on improvable waste lands, the depth of wells, the rainfall and zones of drought, and the parts of the country already irrigated. As another noteworthy instance of the use of maps for statistical illustration, I may mention the interesting 'Carte agricole de la France,' by M. Delesse, which not only shows the extent of arable, meadow, and vine lands, and of woods, but the relative value of land by shades and contour lines of equal revenue. The idea has been adopted by Mr. Ralph Richardson in his map of Mid-Lothian showing the annual rentals by colours; and of course the colours also indicate the positions of barren mountains, of fertile valleys, and of centres of population. Such maps ought to be far more extensively used than is now the case, for in no other way can economic and industrial facts be so lucidly and clearly, as well as so rapidly, impressed on an inquirer's mind.

The third division in which geographical delineation is classed is that comprised in the labour of pioneer-exploring and discovery. This branch of our subject excites the most interest, because the heroic devotion and gallantry of our travellers is a source of just pride to the nation; and because their perils and hardships, their adventures and discoveries surround them with a halo of romance. Yet these romantic associations are not confined to the pioneers of geography. Though

less known, they equally belong to the more scientific geodesist. In the whole range of exploring narrative there is nothing more calculated to excite admiration, nothing more touching, than the devotion of Colonel Lambton, the first superintendent of the Great Trigonometrical Survey of India, the old man who was absorbed in his great work for half a life-time, who wasted away from exposure and hardship, but who, to the last brightened up to renewed animation and vigour when the great theodolite was before him, and who died at his post in a wild part of Central India. This was sixty years ago, but quite recently the equally heroic death of Captain Basevi was recorded. At 17,000 feet above the sea, in a temperature below zero, and protected only by a light tent, this martyr to science was engaged in the delicate operation of swinging the seconds pendulum. One morning, when gallantly striving to rise from a bed of suffering and to recommence work, he died. Nor do these names stand alone. Assuredly, the more scientific surveyors run equal risks, and deserve equal recognition with their exploring brethren. Still the interest justly attaching to new discoveries naturally commands most popular applause, and the importance of opening up an unknown country cannot well be exaggerated.

In this glorious field there are still harvests to be reaped through the bravery and endurance of future travellers. In spite of all that has recently been done in Africa, there is a vast unknown tract to be discovered. In Asia, in New Guinea, in Sumatra and Borneo, in South America, wide regions also remain unexplored. Above all, the greatest problem of this age awaits solution in the far north, and will call forth the best scientific ability, and all the highest qualities of our naval explorers.

Every year, new regions are brought within our knowledge, and we are able to welcome the adventurers home, and to add them to the list of geographical worthies. But, with regard to many explorers, there can be no doubt that much more valuable information might be obtained than is now the case. Men, with various avocations, traverse unexplored or little known countries, who, from want of previous training, are unable to lay down their routes or to observe with scientific accuracy and intelligence. There are naval and military officers, missionaries, consular agents, colonial officials and planters, engineers, telegraphers, collectors, and sportsmen or persons merely travelling for pleasure, many of whom are led, by business or curiosity, to penetrate into regions of which little is known. It is most important that there should exist, in this country, the ready means of furnishing the necessary training to such explorers, and the subject has recently received serious consideration from the Council of the Royal Geographical Society.

It has been resolved that a course of instruction shall be supplied by the Society to all who are about to visit unknown or little known countries, and who desire such training. As a preliminary measure, the present arrangement is to give such instruction as will enable the pupil to fix positions by astronomical observations, and to lay down his route; but this is only a beginning, and it is to be hoped that, in due time, such a course of instruction will be provided as will enable an intelligent traveller to observe with scientific accuracy, and to bring home really valuable results in various branches of inquiry. It is very desirable that this resolution of the Geographical Society should be widely known, and I trust that the local members of this Section will co-operate so far as to bear in mind that this aid is offered by the Geographical Society, when the intention of any native of Hallamshire to visit a distant region comes to their notice. Incalculable good may be done to the cause of geography by a system which will have the effect of making every traveller a scientific and intelligent observer.

The surveying and mapping of the ocean is only second in importance to that of the land; and this work also divides itself into three sections, namely, the coasts surveyed, the coasts partially surveyed, and the unsurveyed coasts. Hydrography will not be completed until all the coasts in the world are included in the first section, which is now very far indeed from being the case. Yet this is not merely a question of science, of the study of the physical geography of the sea, interesting as this branch of our subject has become. Upon the accuracy and completeness of charts hangs the safety of thousands of lives, and the prosperity

of commerce in all parts of the world. When it is remembered how much depends upon the work of marine surveys, it must be a subject of astonishment that so many hundreds of miles of coast line frequented by our shipping remain unsurveyed; and that even, in some cases, when the surveys have been executed and charts published by foreign governments, they are not accessible in an English form. In the interests of humanity and of the well-being of our trade, the efforts of geographers in urging the completion of marine surveys ought to be cordially seconded by Chambers of Commerce, and by all those whose material interests are concerned in the provision of accurate charts of all coasts visited by our shipping.

Hitherto I have invited your attention to the basis of geography, to the measurement of the surface of land and sea, and of their heights and depths; to the mapping of the world, and to the innumerable uses of maps and charts. But this only forms the skeleton of our science, which is endued with flesh and blood, with life and motion, by those who study the causes and nature of the changes that have taken place and are now taking place upon the earth; by comparative and physical geographers, by those who study and classify natural phenomena, and demonstrate their connection with each other and their places in the great scheme of nature.

Geography and geology are, from one point of view, sister sciences. The former treats of the earth as it now is and of changes which have occurred within historical times. The latter deals with the condition of the earth and the changes on its surface which went on during the cycles of ages before the dawn of history. The two sciences are quite distinct, while they aid each other. No geological survey can be undertaken without the previous completion of geographical maps, and the geologist is enabled to comprehend the condition of the earth in remote ages by studying the phenomena of physical geography. On the other hand, the geographer acquires a correct understanding of the present state of the earth's surface by considering the records of those marvellous changes which can be gathered from history and from the narratives of travellers and observers in all ages. Without their services, geography would lose half its interest.

Comparative geography (the study of the changes which have taken place on the earth's surface within historical times) is, therefore, a most important branch of our science; and it enlists the historian and the topographer in our service. It is a branch of geography which has not hitherto received the amount of attention it deserves.

The importance of the study of history and of early narratives for the elucidation of points in physical geography will appear from the consideration of a few instances. Take for example the great and fertile basin of the river Ganges in India. The Sanscrit historian finds reason for the belief that in 3000 B.C. the only habitable part of the alluvial plain of India was the water-parting or ridge between the Sutlej and the Jumna. The rest was a great estuary or arm of the sea. It has only been fit for man's occupation within the historical period, and hundreds of square miles of the delta have become habitable since the days of Lord Clive. The wonderful history of these changes can be traced by the student, who thus enables the geographer to explain the phenomena which he observes. Mr. Blanford, in his charming work on physical geography for the use of Indian schools, supposes a native of the country to be standing on the bank of the river that flows by his village, watching the turbid flood swirling past. The *chur* opposite, which the river left dry when its waters fell at the close of the last rainy season, and which, till lately, was covered by a rich green crop of indigo, is now more than half cut away, and buried beneath the water. Masses, many times larger than the house he lives in, from time to time detach themselves, and are swallowed up by the deep muddy stream. If the Hindu ponders over what he sees he will perhaps be led to make inquiries, and old people will probably tell him that half a century ago the river itself was a moderate sized *khall*, and that the old channel, seven or eight miles off, now little more than a string of pools, was at that time a great river. These facts and their causes will open to him an interesting chapter in physical geography; which is made more complete and more

interesting by the ancient records of his people. But geography is an applied science. This body of facts and their causes is not a subject for mere speculative study only. It is of practical utility; for the knowledge of the way in which Nature has worked in past ages discloses her present and future operations, and enables the enlightened administrator and engineer to work in harmony with them.

Again, to pass to another part of the world. The student of history reads of the great sea fight which King Edward III. fought with the French off Sluys; how, in those days, the merchant vessels came up to the walls of that flourishing seaport by every tide; and how a century later a Portuguese fleet conveyed Isabella from Lisbon, and an English fleet brought Margaret of York from the Thames, to marry successive Dukes of Burgundy at the port of Sluys. In our own time if a modern traveller drives twelve miles out of Bruges across the Dutch frontier he will find a small agricultural town surrounded by corn fields and meadows, and clumps of trees, whence the sea is not in sight from the top of the town-hall steeple. This is Sluys. A physical geographer will seek out the causes which have brought about this surprising change. They are most interesting, and most conducive to an intelligent comprehension of his science, and he will find them recorded in history. Thus the historian and the geographer work hand in hand, each aiding and furthering the researches of the other.

Once more. We turn to the great Baie du Mont Saint Michel, between Normandy and Brittany. In Roman authors we read of the vast forest called 'Setiacum nemus,' in the centre of which an isolated rock arose, surmounted by a temple of Jupiter, once a college of Druidesses. Now the same rock, with its glorious pile dedicated to St. Michael, is surrounded by the sea at high tides. The story of this transformation is even more striking than that of Sluys; and its adequate narration justly earned for M. Manet the gold medal of the French Geographical Society in 1828.

Once again let us turn for a moment to the Mediterranean shores of Spain, and the mountains of Murcia. Those rocky heights, whose peaks stand out against the deep blue sky, hardly support a blade of vegetation. The algarobas and olives at their bases are artificially supplied with soil. It is scarcely credible that these are the same mountains which, according to the forest book of King Alfonso el Sabio, were once clothed to their summits with pines and other forest trees; while soft clouds and mist hung over a rounded shaggy outline of wood, where now the naked rocks make a hard line against the burnished sky. But Arab and Spanish chroniclers alike record the facts, and geographical science explains the cause.

There is scarcely a district in the whole range of the civilised world where some equally interesting geographical story has not been recorded, and where the same valuable lessons may not be taught. This is comparative geography.

The peasant of Bengal sees the mould falling into his turbid river, and learns the first lesson of a course which teaches him the history of the formation of the mighty basin of the Ganges. So should we, in England, to use the words of Professor Huxley, 'seek the meanings of the phenomena offered by the brook which runs through our village, or of the gravel pit whence our roads are mended.' Their meaning is equally significant, equally instructive, and it is thus that we should all begin to learn geography.

Here, in this valley of the Don, as elsewhere throughout England and the wide world, the lessons of geography are open for you to learn. I intend, with the permission of the Section, to conclude this address by referring to the physical geography of the basin of the river Don, not presuming to teach the natives those natural features which they must needs know far better than I, but endeavouring to point out how each feature has its lesson to teach, which bears on questions relating to distant lands, and how a man may become a sound practical geographer without going more than twenty miles from his own door. In this way I would urge all my countrymen whose destiny is not to travel far afield, by studying the geography of their own native district, to acquire a comprehensive grounding which will fit them to discuss more general geographical questions relating to broader problems and more distant regions.

Your own poet had all the instincts of a true geographer: he who sang of your—

> Five rivers, like the fingers of a hand,
> Flung from black mountains, mingle, and are one
> Where sweetest valleys quit the wild and grand
> And eldest forests o'er the sylvan Don,
> Bid their immortal brother journey on,
> A stately pilgrim, watched by all the hills.

In the region watered by that river there are doubtless many others whose unspoken thoughts often echo the words of the Sheffield poet, and to whom I would fain speak of the valley of the Don and its geographical features.

Afterwards the Section will be occupied with several important papers teaching us lessons, and telling us most valuable stories relating to other and more distant parts of the world. In the few remarks I have now addressed to the Section, I have endeavoured to introduce the subjects of those papers, by touching upon the position of geography as a science, and on the numerous practical uses to which our various results can be applied. These uses will appear in their concrete form in the papers which will occupy us during the present and ensuing meetings.

PART II.

THE VALLEY OF THE DON.

In discussing the geography of the valley of the Don, the river basin in which Sheffield is situated, I am anxious again to assure the local members of this Section that I do not presume to give lessons to them respecting their own country. My objects are rather to point out the ready means of acquiring geographical knowledge at their own doors, and to explain the connection between geography and other sciences, especially geology, by making use of the illustrations furnished by a special region.

I shall endeavour to show you, although geography requires the aid of other sciences—of geology in explaining the physical phenomena on the earth's surface; of ethnology, in treating of the effects of climate and other physical conditions on the races of men; of botany and zoology in studying the distribution of plants and animals; of meteorology; and of history in telling us of the changes that have been progressing in former ages—that nevertheless our science forms a distinct body of knowledge, with its own objects, and its own methods of research.

The river basin of the Don, the region of which Sheffield is the capital, occupies an area of 600 square miles, and is about 40 miles in length by 15 to 20 miles wide. It extends from the central water-parting of England eastward to the tidal waters of the Ouse; and from the sea level to the highest peaks on the water-parting there is a rise of nearly 2,000 feet. At the first glance over this region we see at once how diversified are the physical features it presents, from craggy heights round the sources of the Don to the levels of Hatfield Chase and Thorne Waste. This diversity assists an inhabitant to study, round his own home, many of the geographical problems which he reads or hears of in connection with distant regions, where nature has worked on a grander or more extended scale. Instead of confining himself to the study of books, he may go to the book of nature which is open before him, and to which he will return with ever-increasing delight and interest. For almost every geographical point that he meets with in the course of study will be found illustrated in the physical features of his native river-basin; and if the chances of life lead to his becoming a traveller in distant lands, he can have had no better training than a study of the valley of the Don affords.

A range of mountains containing the sources of the Don extends for some twenty miles, and forms the western rim of the river basin. To the north is Ramsden Clough, where the Don and Calder take their rise, and near here the Holme Moss attains a height of 1,860 feet. The country is diversified by high hills of

moorland and deep valleys, through which the Don makes its way until it reaches Penistone, when it takes a sharp turn to the south, and flows along the eastern skirts of the hills, receiving several tributaries. First, the Little Don rises on Langsett and Harden Moors, and falls into the parent stream at Deep Car. Next comes the Ewden Beck flowing down a moorland dell, and joining the Don opposite to the woods of Wharncliffe. The Locksley rises in a desolate and mountainous waste on the borders of Derbyshire, and is at first a torrent—the Dale Dyke, dashing over a rocky bed amidst beautiful and romantic scenery, so well described by Mr. Davis: 'Lower down there are scattered hamlets, sylvan nooks of rare loveliness, villages nestled under the shelter of the hills, shaded by overhanging woods. At the village of Locksley the scenery becomes very beautiful. The river runs through a narrow gorge, with precipitous crags on either side, and, at Malin Bridge it opens on a plain where the Locksley and Rivelin unite, and falls into the Don.' Lastly, the Sheaf and Porter brooks, flowing through vales which were once very beautiful, unite in this town of Sheffield, and also send their waters to swell the Don. Ebenezer Elliott, the poet of this district, had the true spirit of a geographer when, with a light but accurate touch, he swiftly strikes note after note of his homely lyre, at each touch calling up a clear memory in the mind of his fellow-townsmen:—

> Say, shall we wander where, through warriors' graves,
> The infant *Yewden*, mountain cradled, trills
> Her Doric notes? Or where the *Locksley* raves
> Of broil and battle, and the rocks and caves
> Dream yet of ancient days? Or where the sky
> Darkens o'er *Rivelin*, the clear and cold,
> That throws his blue length, like a snake, from high?
> Or where deep azure brightens into gold,
> O'er *Sheaf*, that mourns in Eden? Or where, roll'd
> On tawny sands, through regions passion wild
> And groves of love, in jealous beauty dark,
> Complains the *Porter*, Nature's thwarted child,
> Born in the waste, like headlong *Wyming*.

These tributaries drain the wild moorlands, while the river which receives them flows from north to south, from Penistone to Sheffield, down a deep glen along the foot of the western hills, and confined on the east by the steep forest-clad escarpment of Wharncliffe, with a background of higher fells.

At Sheffield the Don entirely alters its course, turning to the north-east, and flowing through a country diversified by high hills and deep valleys, but still far less rugged and lofty than the western hills, which are drained by the torrent-like affluents. Here the Don receives the Rother from the south; and some miles further on, the Dearne, with a course entirely within this lower and less rugged country, enters from the northern side.

Readers of 'Ivanhoe' will remember that this is 'the pleasant district of merry England, watered by the river Don, where extended in ancient times a large forest, covering the greater part of the beautiful hills and valleys which lie between Sheffield and the pleasant town of Doncaster.' At Locksley, in the mountain glen above Sheffield, was the birthplace of bold Robin Hood, all this region was the scene of his exploits, and away to the east, in the same river-basin of the Don, is Robin Hood's well, and Barnesdale—scene of the encounter described in the ballad of 'Guy of Gisborne.' As the Don, in this part of its course, approaches the old castle of Conisborough, it enters upon a fertile stretch of meadow land. Sir Walter Scott, in 'Ivanhoe,' says that 'there are few more beautiful or striking scenes in England than are presented by the vicinity of this ancient fortress; where the soft and gentle river Don sweeps through an amphitheatre in which cultivation is richly blended with woodland.'

After leaving Conisborough a change takes place in the scenery. There is a plateau, some four or five miles in width, and extending north and south across the river-basin, terminating on the west with a clearly defined escarpment.

Through this plateau both the Don and its tributary the Went, flowing in a parallel course to the north, have to force their way. The rivers flow through narrow valleys of fertile pasture bordered by undulating wooded banks, and the western escarpment, in the Went valley, is bold and picturesque. Leaving this region at Hexthorpe, the Don enters a level plain which, beyond Doncaster, is in places overlaid with peat, and there are wide stretches of marsh-lands called *carrs*; a vast level extending to the Humber.

Such are the general features of the Don river-basin, which would strike the least observant traveller. But the physical geographer investigates and explains the occurrence of these features. He inquires why the western hills are the loftiest and most craggy; why the Don changes its course and flows in a deep trough along their skirts; why the adjoining country, though still hilly, is softer in outline. He examines into the reason of the existence of a belt of plateau land through which the Don and Went have to pass in scarped ravines; and into the causes which have led to the formation of the vast levels extending from Doncaster to the Humber. In these researches, our science receives aid from geology, which tells us the nature of the various rocks and the influence they have on the varying features of the earth's surface as we now see it. We do not concern ourselves with the way in which the rocks were originally formed, with lists of fossils with long Latinized names, or with the condition of the earth's surface in the remote ages when those fossils were living creatures. We are only interested to know the nature and texture of the rocks as they now exist, the order of their deposition, and their economic uses. This information teaches us the causes which have produced the varied configuration of the surface as we now see it.

Geology tells us the story of the formation of the Penine range of mountains where the Don and its tributaries have their sources. The disturbances which the beds of rock have undergone have had the effect of crumpling them up into a number of troughs and arches. As each arch was raised up, the denudation took slice after slice off its crest, so that along the saddle of each anticlinal line the lower beds were laid bare, and now appear on the surface. The Pennine anticlinal, of which the hills containing the sources of the Don form a part, is a broad arch extending north and south from Scotland to Derbyshire. Along the central line of this arch, in the part whence flow the Don sources, the hard massive sandstones of the millstone-grit come out and, on account of their hardness, stand up in a chain of rugged and lofty hills and moorland plateaux. It is the hardness of the rock in the millstone-grit formation which produces the strongly featured country of this part of the Penine range, and, by offering greater resistance to denudation, maintains the superior height of these hills over all the country on both sides.

Where the Don makes its great southerly bend from Penistone to Sheffield the surface formation has changed, its course is then over the lower coal measures and skirting the edge of the millstone-grit. In this fact, no doubt, is to be found the reason of the direction taken by the river. The country where the lower coal measures form the surface shows a repetition of the features of the millstone-grit region, but somewhat less marked, and with less elevation.

On leaving Sheffield, the Don changes its course and enters the country of the middle coal measures, where the bold features which characterise the lower coal measures and the millstone-grit are missing. Here again there are indications of the causes which decided the direction of the river bed. There are two faults ranging in a north-east direction from Sheffield, along either side of the valley of the Don, towards Conisborough, and between these faults the rocks are much contorted. The southerly Don fault passes S.W. to N.E. through Sheffield, along the south-east margin of the Don valley to near Aldwark, and runs on by Thrybergh and Hooton Roberts to Cadeby. The thick beds of sandstone which alternate with the coal in this formation often form bold escarpments, such as the ridge which adds so much to the beauty of Wentworth Park.

We can next account for the picturesque ravines through which the Don and Went find their way before reaching the levels. For here is the more recent Permian formation of magnesian limestone which extends in a narrow belt, four or

five miles in width, right across Yorkshire from the North Riding to Nottinghamshire. Wherever the rivers force their way across this limestone, we find picturesque scenery. Outside the Don valley we have Jackdaw Crags, near Thorparch, rising over the river Wharfe and Anston Rocks to the south, within the Trent drainage system. On the south-east bank of the Don also there is a bold escarpment; and the Went is, on either hand, bounded by precipices of limestone, where it cuts its way through the Permian formation.

Eastward of the magnesian limestone, which forms a distinct escarpment across the river-basin from north to south, is the Trias formation, consisting of the deep red Bunter Sandstone on which the town of Doncaster is built. But the Trias only occurs in patches, and is generally overlaid by the muddy deposits from the Humber, on which are the wide expanses of level peat moss, ranging from 1 to 20 feet in thickness. In cutting through this peat, cones of Scotch firs have been plentifully found, and in the lower layers there are stumps of trees firmly rooted into the sand, proving that a forest once grew there.

It will have been seen how the geology of the Don basin helps us to understand its physical features. The different formations decide the position of the water-parting, the direction of the drainage, and even the character of the scenery. A knowledge is often desirable, not only of the surface rock, but also of the formation which underlies it. When, for example, the magnesian limestone rests on a hard sandstone, its escarpment often rises to more importance than when its foundations are on a softer rock.

The distribution of plants, which is another and a very interesting branch of inquiry in the study of physical geography, is decided chiefly by climate and altitude above the sea, but it also depends a good deal upon the soils and the formations from which they come, and here again geology is useful to the geographer.

On the millstone-grit mountains we find high Alpine plants, but not in such abundance as in other parts of the Penine range to the north, when it reaches a higher altitude, and where the mountain limestone comes to the surface; and we are told that the characteristic of this formation is many individuals but few species. The ivy-leaved campanula is found by the moorland rills, pennywort grows wild at Bradfield, and the hills contain a rare fern (*Asplenium lanceolatum*) discovered by Dr. Gatty, the locality of which is wisely kept a secret from ruthless collectors. But the oak is the prevalent and self-sown tree on this gritstone soil, and is indigenous in the beautiful woods of Wharncliffe. Elliot sings of the 'Rivelin Oak,' and Evelyn, in his 'Sylva,' records the gigantic size of some of the trees in Sheffield Park.

In the valley of the Dearne, and generally over the coal measures, the *flora* is not rich. The alternations of shales and clay hold the rainfall above them, instead of allowing it to filter quickly away, and cause a wet and stiff soil. In the Permian formation, on the other hand, there are many uncommon limestone-loving plants, and the levels beyond Doncaster abound in marsh plants.

A cursory study of the floras in these several formations, guided by the labours of botanists, will enable the geographer to appreciate the causes which influence the distribution of plants, and the various effects of soils, altitude above the sea, moisture and temperature. In extending his view, he would compare the flora of the Don river-basin with those of neighbouring basins, and thus obtain a knowledge of the comparative flora of a wider region, and of the influences which regulate its distribution. There cannot be any better training for the study of botanical geography on a broader and more general scale.

Meteorology is also an important element in the study of physical geography, not only as determining climate, and its influence on plant distribution, but as affecting the hydrography of a region, and the amount and rapidity of denudation. Its study should not be confined to mere registration, the barren results of which have too often been demonstrated. It is very seldom that reliable observations range over a sufficiently long time to give useful results even in countries where there is a trigonometrical survey (the height of civilisation), and scarcely ever in less advanced districts. In Mr. Harrison's interesting history of the flood of 1864, I notice a record of the rainfall in the Dale Dyke valley, varying from 46 inches

in 1859 to 38 in 1861; and at Barnsley, within the Don valley, there was an extraordinary difference between the annual rainfalls of two succeeding years, namely, 42 inches in 1872, and 16 in 1873. The latter example shows the necessity for a series of observations extending over many years. The geographer, in his meteorological researches, should not of course neglect registration. On the contrary, he should be habitually exact on this point; but he should be careful, at the same time, to collect all kinds of information respecting normal and abnormal seasons, and all other particulars which might serve both to supplement and to check his observations.

In all these branches of the subject the comparative elements should be kept in view. We must look back as far as the records of history will allow us, to learn the causes of the present state of the surface of our district, from its past condition at various historical epochs. It is here that the historian and the topographer come to our aid. Time is a powerful and active agent in these changes; but the most interesting and instructive side of the subject is the examination of the effects of human agency in the changes on the earth's surface.

From this point of view the history of a mountain range frequently offers a most valuable subject for study. Mountains usually supply within themselves a natural regulator which checks the rapid flow of the rain water in surface drainage. The absence of such a regulator causes disastrous floods. The regulator acts as a sponge, and is supplied either in the form of a large area of forest, of swamps or peat bogs, of a system of lakes, or of artificial reservoirs. Where there are no forests, nature usually supplies their place with swampy moors.

The surface of the wild moors where the springs of the Don and its tributaries take their rise is covered with heath and ferns, and in winter, after heavy rains, the ground is spongy, and persons have been lost and buried in it. A knowledge of these moors explains the route taken by William the Conqueror in February 1070, in his winter march from York to Chester. The horses of the knights were swallowed up by the treacherous swamps, and swept away by the torrents; and the record of Ordericus Vitalis gives a vivid picture of a march across the Penine chain in mid-winter 800 years ago. In this condition it long remained, and even now the unchanging hills are little altered. But at the same time that cultivation encroached on the moorland sponge, the necessities of great centres of population have called for the construction of large artificial reservoirs, which also serve the purpose of regulating the flow of surface drainage.

There is the artificial lake of Dunford bridge near the main source of the Don. The reservoir at Barker Pool, in use since 1434, appears to have been the first artificial attempt to store water for use in Sheffield, and afterwards a chain of dams in the valley on Crooks Moor met the demand. In 1864 the Dale Dyke or Bradfield Reservoir was completed, covering an area of 78 acres; and on the 11th of March it burst through the dam, making a breach 100 yards long and 70 deep. This appalling catastrophe, so admirably described by Mr. Harrison, shows the irresistible power of floods in motion which, in other countries, are the work of nature unaided by the labours of man. The cataclysms of the Indus, for example, in 1841, and of the Sutlej, in 1819, were caused, not by faulty construction of an engineer's dam, but by the rending away of the shoulder of a mountain which had fallen into the river-beds. But the effects were similar. The lesson of the desolating flood of 1864 was profited by in Sheffield, and the work of storing water proceeded. In 1869 the Agden Dam was completed. The Strines Reservoir was finished in 1872, the Dale Dyke in 1874, and the Dam Flask in 1875, the united area forming, I understand, 300 acres of water.

The necessity for the storage of water, owing to the destruction of forests, and for irrigation purposes, is often a subject of discussion with reference to other mountain ranges, and to disastrous floods in other countries; and the native of Sheffield may acquire a practical knowledge of many sides of an important problem by an observant exploration of the hills and moorlands within a few miles of his own home.

The effects of human agency on the aspects of nature are also very strikingly displayed in the country between Sheffield and Doncaster, and northwards towards

Barnsley and Pontefract. Now this region is alive with busy collieries, iron works and quarry workings—is covered with cultivation and intersected by canals and railways. Within historical times it was a vast forest, with patches of cultivation at long intervals, and dominated by the mighty barons, the Furnivals and Warrens, in the feudal castles of Sheffield and Conisborough. There are still patches of the primæval forests, or at least tracts which have never been under cultivation. The parks of Wentworth and Wortley and Thrybergh have probably never known the plough, and in the smaller area of Aldwark there have been Clarels, Fitzwilliams, and Foljambes for at least six centuries. One would expect to find plants, the survivors of an old forest or marsh flora, in these patches, which are unknown or uncommon elsewhere; and this appears to be the case. We are told, for instance, that at Aldwark the rare *Stellaria glauca* grows, and that the *Carex elongata* has been found there, though not recently. It is probable that many points of geographical interest would be deduced by an intelligent observer who makes a careful comparison of the descriptions of the country in past times with its actual condition.

But the most remarkable effects of man's agency are to be observed in the levels upon which the Don enters after leaving the town of Doncaster.

The vast expanse of levels comprised in Hatfield Chase, Thorne Waste, and Goole Moors covers several square miles. Hatfield Chase alone has an area of 70,000 acres, and was a wild country consisting of forest and moor, intersected by watercourses and dotted with large pools and swamps. The waters of the Don spread over this expanse, the overflow finding its way to the Trent at Adlingfleet. The Idle, now part of the Trent system, also emptied its waters into the great levels. There were large meres or lakes yielding much fish and frequented by all kinds of water-fowl, and boats were the means of communication between Thorne and Hatfield. There were a few islands rising above the level, such as Lindholme, in Hatfield Turf Moor, which could only be reached in seasons of extreme drought. The Earls Warren of Conisborough Castle had a timber-house at Hatfield, whither they went to hunt the deer in a well-stocked park. Here the second son of Edward III., named William of Hatfield, was born, and Henry, the eldest son of Richard Duke of York, in 1441. William of Worcester also mentions another event relating to the Duke of York and the Duchess Cicely as happening at Hatfield, which I need not further particularise. The births of these Plantagenets at Hatfield are only interesting to the geographer because they indicate the nature of the surrounding country, which would afford attractions to that sport-loving race: a wild district abounding in game.

One of these royal hunts took place in 1609, when Henry, Prince of Wales, embarked at Tudworth, accompanied by a hundred boats. Deer, to the number of five hundred, were frighted out of the woods and closes, and all took to the water, being driven into Thorne Mere, where the fattest were killed.

This was the last royal hunt in the Hatfield swamps; for in 1626 the famous undertaking was inaugurated which has effected so marvellous a change in this part of the Don basin. In that year Cornelius Vermuyden, of Tholen in Zealand, with the aid of Dutch capital and Dutch labour, undertook to drain the levels. The south channel of the Don, by which it discharged its waters into the Trent, was to be stopped, and all the waters were forced into the north channel to flow into the Aire. The river Idle, which spread its waters over the level, was to be stopped also, and carried by a new channel into the Trent; and deep drains were to be cut to the Trent from the great ponds and swamps round Thorne and Hatfield. The Dutch labourers, who understood the work thoroughly, made rapid progress; but there was one great mistake in the original design. It was soon found that the north channel could not carry off all the Don water to the Aire, and there was great loss from floodings of the adjacent lands. It then became necessary to make the existing straight cut from the Don to the Ouse at Goole, which is known as the Dutch river, and this added so largely to the cost that it prevented the undertaking from being commercially successful to the first adventurers. Many Dutch families, however, settled on the reclaimed lands; and one of their descendants, Abraham de la Pryme, wrote a history of the undertaking.

The change has been wonderful, and it now seems almost incredible that boats

were once the means of communication between Thorne and Hatfield. The fertility of the banks of the Ouse has also been marvellously increased by the system of warping which was introduced early in the last century. Mr. Ralph Creyke, of Rawcliffe, warped 429 acres, and received the gold medal of the Society of Arts in 1825 for his interesting paper on the subject. Warp is a fine light-brown sediment held in suspension in the river. It is soft and silky to the touch and contains numerous glistening scales of mica. The land to be warped is surrounded by a substantial bank. The water is then admitted, and kept there by closing the flood-gates until the second return of the tide, when it is allowed to flow off. The same process is repeated at the next tide, mud being deposited. Thus either a new soil is created or a thin and poor soil improved, there being 12 to 16 inches deposited in one season, and even more. Indeed, as many as 10 to 15 acres have been known to be covered with 2 to 3 feet of warp during one spring of ten to twelve tides. An expert warp-farmer can, by careful attention to the currents, even temper his soil as he pleases. For the heaviest particles are first deposited, which are those of sand. Then a mixture of sand and fine mud, the most valuable soil. Lastly the pure mud subsides, which is rich but tenacious. The great point is to get the second and mixed deposit over the whole surface, and this is done by keeping the water in constant motion, for the last deposit only takes place in still water. Mr. Caird mentions that fifty years ago Armyn pastures, near Goole, were mostly under water, a breeding-place for wild ducks, and the rest yielded a few cranberries. Now 400 acres are under crops.

We thus see the important influence that human agency has had in determining the character of the earth's surface, and of what consequence a study of the history of that agency must always be to the comparative geographer. Away in the western hills large artificial lakes have altered the face of the wild moorlands. In the region between Sheffield and Doncaster the forest haunts of Robin Hood have disappeared before the collieries and ironworks, the cultivators and quarriers of modern times. In the levels high cultivation and warp-farms occupy the sites of wide lakes and swamps and dreary wastes, while the courses of the rivers have been altered. Kindred changes have taken place or are in progress in other parts of the world, often upon a much larger scale; so that a study of the effects of human agency in the valley of the Don is an admirable training for a more extended examination of the facts of comparative geography.

Our science also occupies itself with the economic statistics of the earth, with the circulation of trade and the products of various regions. Geographers note, for example, the uses of rocks and soils, and the mineral resources of a district. In the millstone-grit range of hills it belongs to geography to record that the lowest grit or *kinderscout* furnishes blocks for engine beds, for foundations, and reservoir works, but that there are difficulties in making use of it owing to the wild and inaccessible character of a great part of the country in which it is found. We should note that the second grit is quarried for road-paving, and that the first or upper grit (called rough rock) is good building-stone; that the lowest underclay of the coal measures is a valuable fire clay which is largely wrought; that the Elland flagstones are extensively quarried and cut into blocks and slabs; and that the magnesian limestone is used for lime-burning and repairing the roads. We should also note the positions and yield of the collieries, the statistics of the iron trade, the agricultural statistics, and the commercial routes, as well as the distribution of population. Many of these vital interests of the region are capable of cartographic illustration.

This region round Sheffield is fortunate in its writers, who have made the road easy for future students. Your very poets, Ebenezer Elliott and James Montgomery, were endowed by nature with geographical instincts. Few districts have had such topographers as Hunter and Eastwood, Holland and Gatty, or so able an antiquary as Mr. Stacye. The authors of the 'Geology of the Yorkshire Coal Field' have furnished you with a detailed history of your rocks; and in their admirable work on the physical geography and botanical topography of West Yorkshire, Mr. James W. Davis and Dr. Lees have rendered you an inestimable service. From their work I have derived many of the ideas and a great deal of the information

which have been submitted to you in this paper; and I must pay my tribute of admiration to the excellence of their design, and to the ability and learning that they have brought to bear on its execution. It is much to be desired that their example should be copied by other workers, and that books on the same plan should be prepared for the rest of England. But a combination of equal energy, learning, and literary skill is not easily to be found.

I have now endeavoured, to the best of my ability, by using illustrations from the river-basin in which this town is situated, to bring to the notice of the Section a complete view of the objects and methods of the science of geography. My aim has been to show that geographical researches may be made within the range of a few miles of your own homes, and that there can be no better training for a geographer than the study of the various branches of inquiry which are comprised in our science, within his own river-basin. If I should succeed in arousing an interest in the subject, in the minds of only a few of the natives of Hallamshire, my object will be attained; for it is by the formation of such small centres of workers that a whole mass is leavened, and it is thus that steady advances in the varied pursuits and objects which are included in human progress are secured.

The following Papers were read:—

1. *The Trade Routes from Bengal to Tibet.*

By Lieut.-Col. T. H. Lewin, *late Deputy Commissioner of Darjiling.*

In the absence of statistics of the actual trade which the author had not had time to obtain from India, a general view only could be given of the nature and extent of the present exports and imports between India and Tibet. The chief wealth of Tibet lies in her flocks and herds; and were the passes open and the roads improved, large quantities of cows, sheep and goats, wool, cheese, and butter would find their way to our territory. At present the export of live stock is limited to the carrying capacity of the animals themselves. The Tibetan traders drive in before them sufficient sheep, goats, or yak to supply them with food on the road, and to carry the goods and merchandise which they bring with them. No trade in live stock is carried on, save that a few ponies come in for sale; and of late years even these have decreased in numbers and increased in price. Other articles brought to India by Tibetan traders, are—coarse woollen blankets and carpets, sheep's wool (to northern and central Himalayan districts), yaks' tails, musk, borax, and rhubarb. The country abounds in minerals, which are not worked, except gold in a rude fashion. The gold-fields extend along the base of the southern watershed of the Brahmaputra, and the gold-diggers come chiefly from the country round Shigatze. But the most important of all the exports from Tibet is brick-tea, obtained from Sze-chuen, from a coarse-tasted leaf, which the inhabitants, however, prefer to the finer teas grown in our own plantations of Assam and the Himalayan valleys. Tea is one of the principal sources of revenue to the Lhasa Government, and the trade is guarded with jealousy from foreign competition. The imports into Tibet are far more important at present than the exports: chief among them are English broadcloths and woollens. The great lack of fuel and the cold dry air of these high mountains render warm clothing an absolute necessity of life, thus the cold-weather clothing of a Tibetan is almost like a vast moving bed, and our English broadcloths are highly prized. The Tibetans are somewhat superstitious as to the colours to be worn. They will not wear blue or black, and only persons of rank wear velvet; their favourite colours are scarlet, purple, a liver-brown, and a snuff-coloured yellow. Turkey-red cloths, prints and flowered calicoes are in good demand. Imitations of Indian handkerchiefs and Cashmere shawls are very popular among the lower classes; chintzes do not seem to be worn. Cottons are not used, save for linings, and also as coverings for sacred pictures. Cheap silk handkerchiefs, especially if the sacred sentence *Om mani paduni houm* were woven into the fabric. There is a good demand for indigo and opium. Quicksilver, vermilion, and red and white lead are also imported in con-

siderable quantities, for gilding the roofs of religious houses. Wall shades, chandeliers, tumblers, wine-glasses, small mirrors, and lanterns find a ready sale. English cutlery, knives and scissors are much prized, and if our manufacturers would condescend to work upon native models a much larger sale would be commanded.

After passing in review the various trade-routes from India to Tibet, *viâ* Assam, Bhutan, Darjiling, and Nepaul, and giving a brief historical sketch of our commercial and political relations with Tibet, Nepaul, and Bhutan, the author summed up by saying that he thought the arguments in favour of a trade route from Darjiling to China *viâ* Tibet were very strong. Lhasa is less than a month's journey for an unladen man from our frontier; once there, the old established trade-routes between Tibet and China are open to us, leading by well-known roads to the great river-basins of the Hoang Ho and the Yang-Tsze. The great province of Sze-chuen, with its 30 millions of inhabitants, would be opened up, and its silk, tea, rhubarb, musk, jade, amber, and cinnabar obtainable in exchange for British manufactures. The inhabitants of Tibet are a peaceful, well-educated and commercially well-disposed race. The routes through Burmah have been tried and have failed. A better route to China may perhaps be found through Assam, but only when railway communication shall be extended up the valley of the Brahmaputra. In future this will be the best road, but for the next 50 years the central route *viâ* Darjiling will no doubt be the best. The Tibetans are Buddhists, and the creed of Buddhism is based on the equality and brotherhood of mankind. It will not be religious intolerance which bars the way to Lhasa; the real obstacles to be contended with are and will be commercial interests. It is the interest of the Lamas or governing classes to exclude us, for, at present, they hold a practical monopoly of the trade, and profit largely both from the duties on important goods, and by the sale of permits to the traders; and it is also the interest of the traders to keep us out; for competition would be ruinous to their present high rate of profits. The real cause of Chinese opposition to us in Tibet lies in their fear that we shall oust them from their commercial and political pre-eminence in the country. In conclusion, the author urged the necessity of our insisting on the carrying out of the privileges with regard to Tibet granted to us by the Chefoo Convention. A clause in this treaty sanctions our intercourse with the country, and authorises our sending a mission thither. This mission should be sent, and we should direct our efforts to establishing permanent trading agents or consuls at Shigatze and Lhasa, or trading-posts on the frontier at Chumbi and Phakri, similar to that possessed by the Russians at Kiachta.

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2. *The Upper Course of the Brahmaputra River.* *By* C. E. D. Black.

The river Sanpu forms a unique and important feature in the geography of Tibet, for the two provinces of U and Tsang occupy its basin from the Mariam-la pass eastward. Until last year the lower course of the Sanpu was a matter of complete uncertainty. Klaproth had contended that its waters discharged themselves into the Irrawaddy (a theory which had been recently revived and ably argued by a geographer in India), while two years ago Colonel Godwin-Austen suggested that the Subansiri might be the lower course of the Sanpu. Although the question cannot be looked upon as settled beyond all possibility of doubt, a recent exploration of its lower course has left very little room for theory in the matter.

The Sanpu rises in Western Tibet in 82° E. longitude and 30° 35′ N. latitude at a height of upwards of 15,000 feet above sea-level. It thence flows eastward over a series of elevated undulating plains, where are found sheep, goats, and yaks. On the south lie gigantic glaciers, clothing the slopes of the central Himalaya. From thence its course lies pretty uniformly eastward, while it is joined both on the right and left by some seven or eight tributaries of varying importance, those from the south appearing to proceed from glaciers, while those from the north by the clearness of their waters would seem to have a different origin. The principal towns lying in the basin of the Sanpu are Jang-lache, Shigatze, and Lhasa. These

are connected with themselves and with Gartok in the extreme north-west by a remarkable road 800 miles long, which follows in a general direction the course of the main river to the junction of the Lhasa river. This road is dotted at intervals by brick-built post-houses for travellers and for the special official messengers who cover the entire distance in an average period of 23 days. The Sanpu is spanned by a few bridges, but these are nearly all unsafe, and the usual method of crossing is by clumsy ferry-boats, which are minutely described by Mr. Bogle, Warren Hastings's envoy.

The furthest point to which the Sanpu had been traced was Chetang, a village the position of which had been fixed by Pundit Nain Singh. In 1877 a native surveyor, N——g, was despatched by General J. T. Walker, Surveyor-General of India, to follow and map out the course of the Sanpu eastward of this point, and as far as possible. Crossing to the northern bank of the river, he followed it eastwards for about 30 miles, and then had to diverge to the north-east and back again towards the south-east for a distance of 50 miles, while the river itself wended its way through impenetrable mountains for about 20 miles. Up to Gyatsa-Jong, the point where he struck the Sanpu again, the river flows pretty much as reported by Nain Singh, but beyond that point it proves to flow first due eastward for about 50 miles and then north-east for about 80 miles. It reaches its most northern point near the intersection of the meridian of 94° with the parallel of 30° about 12 miles to the north-east of a place which the explorer calls Chamkar, and which apparently may be identified with D'Anville's Tchamca. After attaining its most northern point, the river turns due south-east, reaching Gya-la-Singdong in 15 miles. From this point the explorer was unable to follow it. Thence, however, he saw that it flowed on for a great distance, passing through a considerable opening in the mountain ranges, to the west of a high peak called Jung-la. Beyond this opening the river was said to pass through a country inhabited by savages into a land ruled by the British. The distance between Gya-la-Singdong and the highest point hitherto fixed on the Dihong would thus be only about 100 miles. The height of Gya-la-Singdong was found to be 8000 feet, showing that the river had fallen about 3500 feet in 200 miles, and leaving a descent of 7000 feet for the distance of 160 miles to its junction with other Himalayan rivers.

This exploration gives an interesting explanation of the large bulk of the Subansiri, as within the large bend of the Sanpu room is left for a northern feeder of that river. The recent measurement of the discharges of the Assam rivers by Lieutenant Harman[1] also testify to the probability of the Dihong being the only possible lower course of the Sanpu.

Corroborative information of this theory is also supplied by the Abbé Desgodins's researches as communicated to the French Geographical Society, as he had been informed that some days' journey east of Lhasa the river turns southward with a long bend and traversing the Hia-yul district flows into the Lhopa country under the name Dehon.

The combined information thus afforded appears to argue irresistibly in favour of the identity of the Sanpu and Dihong.

3. *The Dutch Expedition to Central Sumatra.*

By Professor P. J. Veth, *President of the Dutch Geographical Society.*

Although we possess in Marsden's 'History of Sumatra' the best and most exhaustive general work on that island, still it is antiquated, and the knowledge of the country in his time was even less complete than it is now. The war in Achen since 1873 has increased our acquaintance with the northern province, and in Central and Southern Sumatra many explorers have recently been at work, especially on the west coast. But an extensive area from the central mountain range towards the east coast yet remains comparatively unknown, and has been taken in hand by the Dutch Geographical Society, which determined to investigate the Jambi district (about equivalent to the Congo in African exploration). The

[1] See *J. Asiatic Society of Bengal*, vol. xlviii. part 2, 1879.

Sultanate of Jambi, comprised in the river basin of the Batang-Hari, is coterminous on the west with the Padang Highlands and Bencoolen, along the water-parting of the island; it is bounded on the south by Palembang, on the north by districts dependent on the Sultan of Liugga, and on the east by the sea. It is watered by a fine navigable river, the Batang-Hari, with several important tributaries, and comprises districts rich in natural products and peopled by industrious inhabitants. Sultan Taha, having been driven inland by the Dutch in 1858, and his uncle Ahmed set up in his place, is naturally opposed to Europeans and averse to exploration. The Dutch Geographical Society, however, sent out an expedition, divided into two parties, one from the west to explore the sources of the Batang-Hari and its affluents; the other under Lieutenant Schoun Santvoort to go up the river in a steam-launch from the east coast, with the intention of meeting the first party. At the end of March 1877, Schoun Santvoort made an unaccompanied successful preliminary journey from Padang, crossing the mountains and descending the river to Jambi in a boat; he then went to Batavia for the launch and returned to Jambi on June 7, but died on November 23, before ascending the river, of the lower part of which he had made an accurate survey. Lieutenant Cornelissen, who succeeded him in command, after two attempts to ascend the river in which he was foiled by native opposition, returned to Jambi, where he remained until last March, collecting information.

The western party, under Mr. Van Hasselt, accompanied by a son of the author of the paper, commenced with a survey of the southern division of the Padang Highlands. Excursions were made for ascertaining the navigability of the affluents of the Batang-Hari, collecting specimens, photographing, and ascending peaks, including Mount Talung and Mount Karinchi (11,820 ft., never before ascended). The precise course and navigability of the main river was ascertained for a considerable distance, and a considerable bend towards the north discovered; this is of great importance, as it brings the river nearer than was expected to the valuable coalfields of the valley of the river Ombilin, for which an east coast outlet is required in the direction of Singapore and Batavia. The name Ombilin is given to the upper course of the Indragini, which falls into the sea north of the Batang-Hari, but is not supposed to be so large or so navigable. In January 1878 the party returned to Padang, intending to start for the interior from Palembang on the south. Accordingly, Van Hasselt and Veth went up the river Musa and its affluent the Rawas by boat to Muara Rupit, whence they marched to Surulangum, the residence of the chief officer in Rawas, the northern district of Palembang. Pending negotiations with Payung Putik, the only friendly chief, an endeavour to penetrate the district of Batang Asei in Jambi was not successful. The district of Lebang was, however, visited, and the explorers advanced through it to Rejang, returning to Surulangum in June 1878, through Sindang. Photographs and ethnological and zoological collections were secured during this part of the journey. The friendly chief having declared his readiness to admit the party, Van Hasselt and Veth crossed the frontier and reached the Limun, a feeder of the Tambesi, the main southern tributary of the Batang-Hari. They got as far as Temiang on the Limun, which is about thirty miles distant from the farthest point reached by Cornelissen in his ascent from the east coast, but were then compelled to retreat by a muster in force, finally reaching Surulangum on July 9, all exploration from Palembang being abandoned. Van Hasselt then joined Cornelissen at Jambi, returning overland to Padang, and Veth crossed the entire Palembang Residency on foot, reaching Jambi in September. Both have now returned to Holland, with many valuable observations and collections. The most important result of this expedition is the gain in knowledge of the great extent and capabilities of the Batang-Hari, which is found to be about 210 miles in length in a straight line, and over 490 miles following its windings, being in fact larger than the Musi or Palembang, hitherto considered the only large river in Sumatra. It is practicable for small prahus, used in transport of merchandise, for 480 miles; and the steam-launch drawing $3\frac{1}{2}$ ft. could navigate it for 370 miles, both these distances far exceeding the navigable portion of the Musi. Its tributaries are also navigable for boats, and one of them at least for the launch. The population of its district as a whole is scanty, yet there are numerous villages close to each other; cattle

abound in the highlands, and coffee is largely cultivated in Karinchi. The importance of the river as a highway for the eastern parts of the West Coast Government and the inland districts of Jambi and Karinchi does not therefore merely depend upon its fitness for transport of coal from the Ombilin valley.

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4. *Discovery of the Sources of the Chico in Southern Patagonia.* *By* Don Ramon Lista.

After a summary of the chief physical characteristics of Patagonia and its people, and a brief mention of the chief authorities referring to that country, this paper described the explorations of Don Ramon Lista, who in 1878 was sent by the Buenos Ayres Government and the Sociedad Cientifica Argentina to investigate Southern Patagonia for scientific purposes. Having landed at Punta Arenas in the Straits of Magellan in March, after a careful examination of the mines there he set out in mid-August on his northward journey. After passing the Santa Cruz valley, the exploration of the course of the Chico commenced, being the important part of the undertaking. At the end of September the confluence of the Shehuen and Chico was reached, and the valley of the latter followed past the curious isolated basaltic rock Mawaish, to the confluence of a new river on the north side, named Belgrano by the traveller. On the 19th, a lake was discovered four miles long and two broad, fed by several streams. The valleys at the foot of the Cordillera were thickly clothed with fragrant, evergreen, antarctic beeches of very large size and great age, only found on the skirts of the Andes. Above these trees, at the extreme point reached, Señor Lista planted the flag of the Argentine Confederation. Having examined the two northern sources of the Chico, the southern one was also explored, and on October 30 the party returned eastward, reaching an encampment of friendly Tehuelches in the Shehuen Valley on November 6. These Indians are divided into two great tribes, one inhabiting northern Patagonia, between the Chubut and Limay, and the other wandering between the Chubut and the Straits of Magellan. These main divisions contain many smaller clans, under about ten chiefs. The large average stature of the Patagonians is in the main confirmed, the tallest man measured being 6 ft. 4 in. They are indolent and addicted to gambling, but very hospitable and kind, and with the chase as their only occupation. A collection of words now in use made by Señor Lista was found to agree very closely with those given by Pigafetta in 1520.

Geographers are indebted not only to Lista for his explorations of the Chico, but to his predecessor Moreno for his examination of the Santa Cruz and discovery of two lakes. Lista has also brought home many objects of zoological and ethnological interest.

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3. *On Present Italian Geographical Explorations.* *By* G. Dalla Vedova, *Professor of Geography at the University of Rome, Secretary of the Italian Geographical Society.*

After referring to the national difficulties in the way of Italian geographical enterprise, the writer enumerated the following modern voyages of exploration by his countrymen:—

1. That of Renzo Manzoni, of Milan, who has twice journeyed from Aden to Sanah in Yemen. Being prevented by native opposition from penetrating further into the interior both at Sanah and Berbera, he has started for Hadramaut, to make zoological collections.

2. That of Carlo Piaggia, of Lucca, who in March 1879 started from Khartum on his way to the Tumut River, and camped near Famaka for the rainy season. He has probably now left that place, as an invitation has been sent to him by the Milan African Society to command a new expedition.

3. That of the first Milanese Expedition for Commercial Exploration, sent out by a society founded in 1878, with the object of opening up trade in Abyssinia and the Red Sea, under the leadership of Dr. Pellegrino Matteucci, who has entered Tigre and set out for Debra-Tabor to be personally introduced to the chief, Johannes Kassa, after a stay in Adowa. His plan is to reach Shoa and the Galla country.

4. The Italian Expedition to Equatorial Africa. This originated in a subscription promoted three years ago by the Italian Geographical Society, and resulted in the departure in March 1876 of the Marquis Antinori, Engineer Giovanni Chiarini, and Lieutenant Sebastiano Martini-Bernardi, with the object of penetrating to Shoa from Zeila, then turning southwards, crossing the Galla country to the Great Lakes, and returning to Zanzibar. At Harar, on the way to Shoa, Martini was sent back to Europe for fresh supplies, in consequence of theft; he reached Italy and set out again in March 1877 with Captain Cenhi and reached Shoa in the following September, finding Antinori to have lost his right hand by a gun accident. Instead of resuming the proposed journey, Martini was once more obliged to go back to Italy, on a mission from King Menilek, who made this a condition of his support. This accomplished, he once more started from Italy, in March last, reached Zeila, where he was met by a special caravan sent to bring him to Shoa, and started for the interior in July with Count Antonelli and Signor Giulietti, Antinori returning home. Meanwhile Chiarini and Cenhi started in May 1878 for Kaffa, and were last heard from under date of July 20, 1878, at Demekash in the Gurâgwe country. Details of the route from Zeila to Shoa and of the physical and other conditions of the country and its inhabitants; a political history of Shoa, and economical and ethnological accounts of its people and of the Gallas; astronomical determinations of positions; plans and route-maps, &c., have already been received from this expedition, with many zoological and other collections (more of which are on the road). A station has been granted to the Italians in the valley of the River Mantek, and is already for the greater part brought under cultivation.

Besides these four expeditions by Italians, it is to be noted that Lieutenant Giacomo Bove has charge of the hydrographic operations and surveys of Professor Nordenskjöld's N.E. Arctic Expedition, of which he is a member.

FRIDAY, AUGUST 22.

The following Papers were read:—

1. *Journey across Africa from Benguela to Natal.* *By* Major Serpa Pinto.

Starting from Benguela, on the Atlantic coast, Major Pinto proceeded first to Bihé, a native settlement in the interior, crossing different territories subject to the King of Portugal, and rectifying the positions of rivers, mountains, and villages, of which the chief, subject to Portuguese authority, are Quillengues and Caconda. In May, 1878, in obedience to the instructions of the Portuguese Government, by whom he was sent to Africa, he left Bihé, accompanied by good native guides, his principal object being to investigate the hydrographical system of the country to the east-south-east of that place, as far as the Zambesi. This country, forming the southern limit of the Benguelan highlands, stands 5,000 feet above the level of the sea, and possesses great advantages in its salubrity and commercial and agricultural capabilities. It is, in fact, of all tropical Africa the territory most suitable for European colonisation.

Owing to circumstances alien to the wishes of his Government, this journey was performed with scarcely any resources, the party living on the product of the chase with occasional help from friendly natives. The traveller was well supplied with scientific instruments, having two sextants, an artificial horizon, a telescope, several compasses, three hypsometers, a small aneroid, and thermometers. His meteorological observations, however, were not quite continuous for the whole period, on account of interruptions by serious illness. He brought home a great number of chronometrical longitudes, which cannot contain important errors, as his chronometers were continually regulated and were compared with the result of the eclipses of the first satellite of Jupiter. In May, 1878, he had the chance of observing the transit of Mercury across the sun, and such an observation afforded a strictly correct longitude.

Before reaching Bihé the traveller was surprised to meet the Cubango (Kubango) river taking its rise to the west and not to the east of that place, as all existing maps had led him to believe. This large river receives on the east a great affluent, the Cuito (Kwito), which unites its waters with the Cubango at a place called Darico. Within the wide fork formed by the two rivers, the Cuanza (Kwanza, or Quanza) takes its source with some smaller affluents.

Here was remarked a peculiar feature in the physical geography of this part of Africa, viz., the dovetailing of the sources of rivers which in the rest of their courses run in opposite directions. Close to the source of the Cuito rise three other rivers; two of which flow into the Atlantic by the Cuanza (of which they are tributaries), and one into the Indian Ocean through the Zambesi. The same feature is noticeable even beyond Lake Bemba, the Congo and the Zambesi, as well as their affluents having their sources and mingling their streams near the 12th parallel of south latitude. East of the river Cuito, in latitude 13° S. and longitude 19° E., the Cuando (or Kwando, named Chobe by Livingstone, who saw it near its junction with the Zambesi) takes its rise. This is a large, navigable river, watering a great extent of inhabited and fertile country. The Cuando receives several great affluents, as navigable as itself.

In this region, covered by forests and where the elephant still abounds, the traveller found the Mucassequeres, peculiar from their yellowish-white colour. They are nomadic and perfectly savage, spending their time continually wandering in the region between the Cuando and the Cubango. There exists likewise another nomad tribe, the Mussambas, who are black, and wander about to the south, making their raids as far as the country of the Sulatebele. These people are, however, quite distinct from the Massaruas or Bushmen of the Kalahari desert.

The country between Bihé and the Zambesi is inhabited by three distinct races: the Kimbandes, the Luchares, and the Ambuellas. Another race is beginning now to settle there; and there is a considerable emigration of Quibocos (Kibokwes) coming from the north for the purpose of establishing themselves on the banks of the Cubango and the Cuando, in their search of more fertile lands. Major Pinto met large caravans of emigrants, and made a stay in their new settlements.

All the above-mentioned country is splendid, and very fertile; inhabited by people of a docile character, susceptible of development, and strikingly fond of dress, a disposition which points to a great prospective market for the consumption of European manufactures.

These tribes are governed absolutely by independent rulers, and constitute confederations although belonging to different races. The missionary has never reached them, nor had any European been seen among them till the arrival of Major Pinto, who met with a cordial reception.

Travelling eastward, the Liambai (the name given to part of the Zambesi above the Falls) is the first river met with beyond the Cuando. As regards that part of this great river which he examined, Major Pinto found these settlements of races of a very different kind, and of very different customs, from those observed by Livingstone.

He fancies that the Liambai, where it describes its great curve to the westward, lies more to the west than Livingstone supposed. Between the 16th parallel of latitude and the Victoria Falls, a distance of 220 geographical miles, the river has seventy-two cataracts and rapids.

At the time Livingstone first visited this part of Africa, it had recently been conquered by Chibitano (or Sebituane), who induced the native tribes to confederate, thus constituting a powerful empire. Six years afterwards, during the Zambesi Expedition, when he visited Sesheke, Livingstone foretold the extinction of the Makololos, which has since taken place.

Whilst on the Zambesi, Major Pinto met with Machuana, who had been Livingstone's companion on his journey to Loanda, and who, being at that time a slave belonging to King Sekeletu, is now an important individual in his capacity of a Luina.

On the west the Zambesi does not receive between the Liba (Leeba) and the Cuando any other affluents, except the Lungo-é-ungo, and the Nhengo. The latter is formed by the junction of three rivers: the Ninda, the Loati, and the Luanguinga. From the confluence of the Cuando as far as Victoria Falls, it receives only one small stream close to the cataract. South of the Zambesi and the Cuando, the land-surface of the country, which from Bihé had declined some 1,200 feet, began slightly to rise again, and exhibited a rich vegetation. But as far as population is concerned, this part of the country is a desert; and only two settlements were met with, constituting two small villages, Luchuma and Daka, the latter being situated on a different spot from the village bearing the same name, and formerly existing there.

The policy adopted by the Matabeli does not permit of the settling of any tribe on the southern border of the Zambesi. This powerful Zulu tribe look upon that great river as their natural frontier of defence against their enemies the Luinas, and even they themselves do not settle in that country, in consequence of the bad fevers prevailing all along the river banks. The soil, however, is fertile; but the country can never expect a prosperous future, not only in consequence of its climate, but because of the difficulty of access to it from any point on the African coast. Here Major Pinto met Dr. Benjamin Bradshaw, an English zoologist, and José Anchietta, a Portuguese explorer, resident in Africa for eleven years, who holds an official position under the Portuguese Government, and is employed making scientific collections for the Zoological Museum in Lisbon. He also met with a French missionary, M. Coillard, with his wife, a Scotch lady, and their niece, in whose company he made his journey across from the Zambesi to the Bamangwato country, and visited the famous Makarikari, the enormous basin into which run and are evaporated the waters of many different rivers coming from opposite points of African soil. There ends the Botletle, which is nothing else than the Cubango after having made its passage through Lake Ngami. On arriving at Shoshong, the chief town of the Bamangwato, he found its position very different from that which it occupies on maps, as regards longitude.

His journey from Shoshong to Pretoria was full of incident; and no less interesting was that from Pretoria to Natal, during which he had as companion Lieutenant Barker, of the 5th West York.

Major Pinto has only given one new name during his whole journey, viz. Baines's Desert, as he terms the country crossed between the Botletle and the Zambesi; desiring to render honour to Thomas Baines, one of those who have worked most laboriously in the interior of Southern Africa.

Some small zoological collections were made; but the traveller's attention was specially given to the different races, customs, and habits which he had the opportunity of observing during the course of his journey.

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2. *The Basin of the Ogowé.* *By* M. Savorgnan de Brazza.

The largest area in Africa now unexplored is to the north of the equator from the Congo to Lake Chad, and from the Ogowé, on the western side to the country of the Nyam-Nyam, visited by Dr. Schweinfurth. From the western coast this unknown region has been entered by the French Expedition under M. Savorgnan de Brazza and Dr. Ballay, which left Bordeaux in August, 1875, to explore the whole course of the river Ogowé, reaching the Gaboon on October 20. They succeeded in hiring canoes, and commenced the ascent of the river in the following year, making

their first halt at a village called Lopé. From this station Brazza set out to explore the country of the Fans, a very difficult and hazardous journey. Thence the expedition advanced to Doumé, on the upper part of the Ogowé, where its course is from south-east to north-west. Doumé is about 50 miles south of the equator. After a serious illness Brazza was obliged to return to the coast, but he rejoined his party at Doumé in April, 1877, and reached the Poubara Falls in 1° 45′ S. Here the Ogowé, flowing from the south, becomes an insignificant stream, and it was not considered necessary to follow its course any farther.

But here the most important part of M. Brazza's work commenced. He resolved, in spite of the sufferings he and his party had already gone through, and the diminished stock of provisions, to leave the basin of the Ogowé, and penetrate farther eastward into the unknown interior. The region they had to traverse was devastated by famine, and they suffered much from hunger and thirst. After crossing the water-parting, they followed the course of a stream which brought them to a great and previously undiscovered river flowing eastward called the Alima. It was 150 yards in width, and there can be very little doubt that the Alima is a tributary of the Congo. The inhabitants proved to be hostile, a people devoted to war and pillage, and the explorers were attacked from all the villages they passed, and chased by canoes. Leaving the river, they took a northerly course, and crossed several streams flowing to the east, like the Alima. After having crossed the large river Licona, on the equator, and penetrated to a place called Okanga, some 30 miles farther north, M. de Brazza found it necessary to retrace his steps on August 11, 1878, arriving at the Gaboon on November 30. He described the region between the rivers Ogowé and Alima as 50 miles across, consisting of hills of moderate height, with many easy passes.

3. *The Southern Galla Country.* *By* Rev. J. Wakefield.

4. *German Explorations in Africa.* *By* Professor Erman.

5. *The Euphrates Valley Railway.* *By* Commander V. L. Cameron, *R.N.*

6. *On Proposed Indo-Mediterranean Railways, with an Account of a Journey by Land from Bagdad to Bushire.* *By* Wilfrid Scawen Blunt.

After discussing the routes which have been proposed for a railway to Bagdad, viz. by Palmyra, the Euphrates Valley, and the Tigris (all of which are considered more or less impracticable), and also alluding to a possibly feasible line, adhering pretty closely to the existing caravan road which passes through Orfa, Mardin, Nisibin, Mosul, and Kerkuk, approaching Bagdad eventually from the north, the author described his own experiences (in company with his wife, Lady Anne Blunt) of the last 500 miles of the proposed route.

Starting from Bagdad on March 19, Mr. Blunt landed on a peninsula of the Tigris called El Wudian. There are very few settlements on the left bank of the river, partly on account of danger from the Persian frontier, but principally from the indifferent nature of the soil, which contains a good deal of saltpetre and is in parts unhealthily swampy. On the third day the party left in search of a camp of Beni Laam Bedouins, said to be five days' journey off in a nearly easterly direction.

Their road lay across a very barren plain, varied only by occasional swamps, and now and then a patch of spotted thistle, on which their camels fed voraciously. The Hamrin hills are not more than fifteen miles from the river at its nearest point, and run in a perfectly straight line north-west by south-east. There is no cultivation at all away from the river bank, and but a few Bedouins were met, living in groups of only three or four tents together, on account of the scantiness of the pasture. They seldom had camels (for it is a poor camel country), but sheep or goats, and a few half-starved cows.

On the fifth day Mr. Blunt came to the camp situated on the bank of the Tibb, a river about fifty yards wide, and at the ford from three to four feet deep. The Tibb rises beyond the Hamrin hills, which it cuts through, and after flowing for about fifty miles across the plain, joins the Tigris at Amara. They were now close under these hills, and found the soil good and carrying a rich crop of grass.

Here the servants and camel men refused to accompany the party further, as they were afraid to venture across the frontier, which has a very bad reputation as the haunt of robbers and outlaws. Only the cavass remained, and they were forced to load and drive the camels themselves.

About thirty miles from the Tibb, the party came to a very similar river, the Dueri, which they had some difficulty in crossing. It was much swollen by the melting snows, and the horses had to swim. It was not too deep, however, for the camels, and like the Tibb had a good gravelly bottom. Another thirty miles brought them to the Kerkha, a much more formidable river, having a great volume of water three hundred yards across and running at the rate of about six miles an hour. Here they found a Persian prince living in exile with a Kurdish tribe, and put themselves under his protection.

The country passed over between the Tibb and the Kerkha is a low rolling down, the last ripple in fact of the Hamrin hills, bare of trees and bushes, but covered for the most part with excellent sheep pasture. There is, however, an interval of about ten miles immediately east of the Dueri, where desert gravel is found with the usual desert vegetation. The river banks are thickly wooded with tamarisk and arghâl jungle, and are said to contain numerous lions of the Persian breed (not the maneless lion of the Euphrates). The whole of this strip, sixty miles across, is uninhabited, although the pasture is excellent and the country well watered.

They crossed the Kerkha on a raft, and found cultivation and soon after villages on the opposite side. The Kerkha is indeed the boundary here of Persia. The party passed within sight of the ruins of Susa, and the same evening arrived at Dizful.

Dizful is a large town, the capital of the province of Luristan. It contains perhaps 20,000 inhabitants, and is the centre of a considerable trade. It is the market of all the pastoral tribes of the Bactiari mountains, and stands in a really rich agricultural district. Between it and Shuster they passed several villages and a fair amount of cultivation. Shuster is a town of about the same size as Dizful, and both stand upon large rivers resembling the Kerkha, and crossed by ancient stone bridges of twenty and twenty-two arches. These three rivers, uniting lower down, form the Karun, the third of the rivers of Eden.

Once past Shuster the road became deserted. On the whole seventy miles between it and Ramuz they found not a single village, and only three Bedouin encampments. The nomads here again are Arabs, but so poor and so ruthlessly oppressed by the Persian government, that their flocks are unable to pasture a hundredth part of the good grass land, which is abundant and well watered. The soil, a rich red earth, would produce excellent crops and at little cost in labour, for the rainfall here at the edge of the hills may be depended on. The Persian government, however, is systematically destroying agricultural wealth in Arabistan, which, though belonging to Persia, is treated like an enemy's country and is rapidly becoming depopulated. Beyond Ramuz, Mr. Blunt travelled through miles of standing corn, self-sown now for several years, though the deserted villages seemed hardly yet in decay. Gardens with vines and fruit trees still surrounded the houses, but there was nobody to gather the fruit.

Bebahan is a considerable place, equal perhaps to Shuster, and though a decaying town, is still the centre of no little wealth. It stands in a fertile district, and the inhabitants being Persians have been less ruthlessly treated. Bebahan lies, however, out of the direct route to Bushire, and is surrounded by an intricate line of hills, so that a railway could not easily pass that way. It stands about a thousand feet above the sea. The descent towards the coast is by a series of precipitous cliffs, and after passing two more rivers the level plain which skirts the coast is reached. Mr. Blunt struck the Persian Gulf at the little town of Dilam.

From the time Shuster was left, the party had run considerable risk from the

unsettled state of the country, the few villages that remained were at war with each other, and it was almost impossible to induce any one to serve as guide or accompany as servant. On the coast, however, all was comparatively civilised. The inhabitants of the little towns along the Gulf, though given to piracy by sea, are peaceable on shore, and there are no Bedouins to make travelling unsafe. The country indeed is very barren, a uniform plain of saltpetrous clay intersected by tidal creeks and salt morasses. There is but one low range of hills, and these would offer no serious obstacle to a railway.

Mr. Blunt's party had now been travelling for many days and nights almost without rest, and were nearly exhausted from heat and flies. When at last, on April 28, worn out and almost in rags, they alighted at the English Residency at Bushire, the sepoys at the gate refused them entrance. They could not understand that they were British subjects or honest people of any sort.

They had travelled five hundred miles, crossed nine considerable rivers, passed through three large towns and about a dozen villages. About fifty miles of the route had been through well-cultivated districts, and fifty more through intermittent cultivation; the rest may be fairly described as an uninhabited waste.

7. *The Physical Aspects of Zululand and Natal.* *By* BEAUCHAMP TOWER.

The water-parting of this part of South Africa is formed by the Drakensberg, a range of mountains which runs parallel with and about 150 miles from the coast of the Indian Ocean. The descent from the Drakensberg to the sea is over an irregular surface of mountain and valley, the mountains gradually diminishing to low undulating hills near the sea. But between the 27th and 28th parallels of south latitude a range branches out nearly at right angles with the Drakensberg, which is 7000 to 8000 feet high, and again between 29 and 30 S. there is another range between two branches of which stands the capital of Natal. There is thus an area bounded on three sides by mountain ranges, and on the fourth by the sea; which includes the northern part of Natal, nearly all Zululand, and the SE. corner of the Transvaal.

This area is one mass of alternate mountains and valleys; many of the hills having a peculiar table-topped form. They are of granite capped by huge slabs of sandstone, which seem the remnant of a broadly spread pavement formerly continuous with the central table land. One of the finest specimens of these table mountains is the Inhlazatye, which rises on the north bank of the White Umvolosi to a height of about 6000 feet. The principal river is the Tugela, which drains the greater part of the area. The only others of any size are the Umvoti, on the Natal side, and the Umlatoosi and Umvolosi in Zululand. After describing the rivers, Mr. Tower dwelt upon the beauty of the scenery, and gave some details respecting the climate, the vegetation, and the character and habits of the people.

SATURDAY, AUGUST 23.

The Section did not meet.

MONDAY, AUGUST 25.

The following Papers were read:—

1. *Afghan War—The Jellalabad Region.* *By* WILLIAM SIMPSON, *Special Artist of 'The Illustrated London News.'*

Having been attached to the Peshawur Field Force under General Sir Samuel Browne, the author accompanied it from the Khyber as far as Gundumuck. The troops were quartered for over three months at Jellalabad, and during that time he had opportunities for making himself acquainted with the region. The tendency of his explorations, beyond his own proper sphere as an artist, was rather archæological than geographical. Still, the ancient remains of a country belong undoubtedly to its geography, and have in all cases to be considered as a portion of our knowledge of any locality under consideration; and no account of the Jellalabad Valley would be complete without some notice of the Buddhist remains to be found there. Mr. Simpson was aware previously of the existence of these remains, but what astonished him was the vast quantity of them still to be seen. On all sides are extensive mounds and heaps, that being the condition in most cases of these remains. Here and there structures may be found, which, although in ruins, yet bear on them some traces of architecture. At Hada, about five miles south of Jellalabad, are some elevated ridges, extending to a considerable distance; these are in the present day a mass of undulating heaps, marking the site of a city of monasteries and shrines, which was celebrated in the Buddhist period. This is about the only one of these Buddhist groups which has retained its ancient name: it was called Hi-lo, or Hidda, by Fah Hian. Here, we know from the Chinese Pilgrims, was exhibited in a most costly shrine the skull-bone of Buddha; and not far from this was a cave with a miraculous shadow of Buddha, a spot which the Buddhist devotees all visited. At the western end of the valley, on the south of the road to Kabool, there are some low hills of conglomerate; here for a number of miles are caves, mounds, and topes—the remains of what have been Buddhist monasteries. The western end of the Jellalabad Valley is terminated by the Siah Koh, or 'Black Mountain' range, and along the base of this rocky mass, towards Duranta, is another extensive collection of similar ruins. Here some of the topes are not so dilapidated, and their architectural features can still be traced. Crossing the Kabool River we find, on the left bank, about a mile or so from Duranta, another very large group of mounds, topes, and caves. This group extends for about three miles. On the same side of the river are the districts of Besoot and Kamah. Although not so familiar with them, still, in an expedition which the author accompanied against the Momonds, he noted the existence of Buddhist remains on the lower ridges of the hills; as a rule, elevated ground seems generally to have been selected for these religious establishments, and they all commanded good views of the valley. At Mirza Kheyl, which is in the Kamah district, and close on the eastern end of the valley, is a mass of white rock covered with remains. Near this is an island in the river called Girdao, with the ruins of an extensive monastery. This list of the larger groups is far from being exhaustive, on account of numerous remains of lesser importance scattered about.

One point is apparently clear, that in the Buddhist period the population of the Jellalabad Valley must have been much more numerous than at present, and that the area of cultivation must have been also more extensive. The topes were large and elaborate architectural structures, and the author believes the same might be said of the monasteries, for the explorations produced sculptures and plaster figures in great quantities, which had been all painted with bright colours, and in many cases thickly gilt. The wealth necessary to construct such a mass of buildings, as well as the maintenance of them, and the large population of monks who lived in these places, must have been great. The scanty number of people in the region at this day would be quite insufficient to support them. The Buddhist ascetic priests

must have been, judging by the remains, two or three times greater than the present population. Kamah is well cultivated, but on the Jellalabad side there is only a narrow strip along the bank of the Kabool and Surkhab rivers under cultivation; the remainder of the valley is covered with sand and boulders. At Girdi Kas, where the river flows out of the valley at the eastern end, are the remains of an aqueduct and an old road. The last is known as the Badshah-i-Rah, or the 'Imperial Road,' and it was supposed from its name to have been made by one of the Emperors of India. Our engineers made repairs on this road, and from the officers engaged on this work Mr. Simpson received the information that portions of 'Buddhist masonry' are still to be seen on it, showing it is older than the Badshahs who ruled in Delhi, and that regularly constructed ways were made in the more civilised period of Buddhism, a kind of public work which the Afghan has long ceased to trouble himself about. While the engineers were at work at this spot, they also discovered an old aqueduct constructed along with the road, with a considerable tunnel through one of the hills by which the water was led to the Chardeh Plain, on the east of the Jellalabad Valley, and which is now a desert of stones, and so dangerous from heat that no native of the country, they were told, would venture to pass over it in June or July in the daytime. The aqueduct discovered by the officers is a pretty clear evidence that this wilderness of boulders was at some former period under cultivation. In this case archæology is of some value as throwing light on the past, and the contrast is not favourable to the condition of the country in its present condition. Further valuable light drawn from the same source was afforded by Major Cavagnari (now Sir Pierre Louis Napoleon Cavagnari), supplying the author with a working party to make excavations at the Ahin Posh Tope, about a mile south from Jellalabad. The principal object was to explore the architectural details of the remains, but while thus engaged, the author penetrated, by means of a tunnel, cut for about 45 feet through solid masonry, to the central cell of the shrine, and found along with what were most probably the ashes of some Buddhist saint of high repute, twenty gold coins, each about the size of a sovereign. Seventeen of these were Bactrian, or Indo-Scythian; and three were Roman. One belonged to Domitian, another to Trajan, and the third to 'Sabina Augusta,' the wife of Hadrian. Evidence of a road has already been given, and these coins prove that at a past date a commerce went along that road; and it must have been a commerce of considerable importance which brought coins all the way from ancient Rome in its track.

We know that in the Buddhist period the capital city of the Jellalabad region was called Nagarahara. When Mr. Simpson started for the Afghan War, Colonel Yule called his attention to this, as a point of importance, and that the fixing of its site would be of some value. This task the author thinks he has accomplished. About four miles to the west of Jellalabad there is an isolated rock which stands up out of the plain. It is covered with the *débris* of former structures, amidst which a little careful examination soon discovers remains of 'Buddhist masonry.' This rock, the natives say, was the Bala Hissar of an old Kaffir city. The word 'Kaffir' means, in the mouth of a Mahomedan, an 'infidel,' and they apply the word to everything pre-Mahomedan; hence all the old Buddhist remains they tell you are 'Kaffir log Ke.' There are long mounds to be seen in different places around, apparently the vestiges of the old walls, and the quantity of stones scattered about has led the people to call the place Wuttapoor, or the 'City of Stones.' It is also called Begram, which some authorities have rendered 'Chief City.' Our surveyors, in the new map made during the campaign, give one place here, for there are a number of villages within the space of the old city, as 'Nagarat,' which is no doubt a contraction of Nagarahara—Fah Hian, the Buddhist Pilgrim, uses the word 'Nagrak' (Beal's Trans., p. 40). Close to the old rock the author made a very partial exploration of a large tope, and the name of it as given by the villagers was Nagara Goondi, the last word here meaning a 'knoll' or 'mound,' and which is used in relation to all topes when they have been reduced to a simple heap. This name would therefore mean the 'Nagara Tope,' and in these words Mr. Simpson thinks we have the remains of the old name, and they form a very strong evidence, when added to what is already given, that this is the site of the old Buddhist city of Nagarahara. Its position would have been a strong one. It was

protected on the north by the Kabool river, and on the west by the Surkhab, and there is another smaller stream on the east, which may have been the boundary on that side. On the opposite bank of the river is the Pheel Khana group of topes and caves, which would overlook the city, and form a picturesque suburb in that direction; on the west there would be the Duranta monasteries on the lower skirts of the Siah Koh, also overlooking the city and forming another pleasant suburb for the Buddhist devotees of the city to stroll to and worship at the various shrines. The Char Bagh group is a little more distant on the south, but still near enough to be looked upon as a part of the capital city. The city, when in its days of splendour, was not only a fine one, securely situated, and surrounded with imposing architectural temples and monastical buildings full of statues and pictures, resplendent with gold and every bright colour, but it was a good strategical situation, commanding at once the entrance to Lughman, the Kunar Valley, and the high road to Kabool.

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2. *Afghan War.—The Kuram Valley.* *By* Captain GERALD MARTIN.

Captain Gerald Martin (writing from the Peiwar Kotal) reported on the survey operations conducted by officers of the Indian Survey Department attached to the 'Kuram Column' of the Afghanistan expeditionary force. Captain Woodthorpe, Captain Martin, and Lieutenant Manners Smith were the surveyors, and the area comprised the whole of the Kuram Valley and the district of Khost to the south, representing an addition to our geographical knowledge of 4,500 square miles. Captain Martin gave a short summary of the movements of the troops, including the battle on the Peiwar Pass, the march to Shutor-gardan, the action in the Mangior defile, and the advance into Khost. The surveyors accompanied all the more important reconnaissances.

The report then described the sources and the course of the river Kuram, with its numerous tributaries, as well as the Shamil and other rivers in Khost. The account of the rivers was followed by an enumeration and description of all the principal routes up the Kuram Valley, and of those branching from it to Khost or across the Safaid-Koh range to Jellalabad. The towns, or rather chief villages, were then enumerated and described, and some information was given respecting the climate of the Kuram Valley. Captain Martin next gave a general description of the country, dwelling on the beauty of the scenery at several points, and specially on the magnificent views of the Safaid-Koh and other mountain ranges. Several peaks and important passes in the Safaid-Koh range were visited by the surveyors, and Captain Martin gave an interesting account of journeys to the Lakerai and Shutor-gardan Passes, and of an ascent of the Sikeram peak, the loftiest in the Safaid-Koh range, and 15,600 feet above the sea. He also explained the great value of the heliograph in field signalling, and for triangulation. During this expedition communication was kept up by means of a 3-inch heliograph, at a distance of 34 miles.

The paper concluded with a very interesting account of the botany of the Kuram Valley and of its forest-clad slopes (which was furnished by Dr. Aitchison), and with a detailed account of the Hill tribes.

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3. *Afghan War.—Country between Kandahar and Girishk.*
By Captain R. BEAVAN, *F.R.G.S.*

Captain R. Beavan, F.R.G.S. (writing from Kandahar), describes the country between Kandahar and Girishk, which was traversed by the division under the command of Major-General Biddulph in January and February, 1879. Girishk, on the right bank of the river Halmand, is of great importance as a military position, because it lies at the extremity of the vast mountain masses that break up the whole country between the Halmand and the Arghastán into a troubled sea of rock. Skirting the route to the south lies the great sandy desert, equally impassable for troops. Thus the tract from Girishk to Kandahar forms practically the sole mili-

tary passage between India on the one hand, and Persia or Turkistan on the other. It is for armies what the Suez Canal is for ships.

The narrow strip of plain which this route traverses forms the interval between the desert and the hilly country. The desert rolls up in undulating sand hills from the far south. It is bounded by the rivers Arghandab and Dori, the thin lines of running water seeming as if they had some magic influence in restraining the overflow of the sand. To the north are the mountains, bare and rugged, not a sign of verdure anywhere about them, not an indication of moisture. The great peculiarity of the country is that only the upper portions of the hills are exposed above ground. The whole country, including the lateral valleys, appears to have been filled up at a date subsequent to the elevation of the hills with a deposit of rubble, waterworn boulders and pebbles, with hardly sufficient soil to hold them together. The elevation of this part of the country is over 3,000 feet above the sea. This deposit, though apparently level, in reality slopes considerably upwards from the rivers to the base of the hills, while the valleys have a slope in the direction of their length. Captain Beavan then explained how this formation aided the peculiar system of irrigation by means of *karez* or underground aqueducts, which is constantly made use of in this part of Afghanistan.

At the junction of the two rivers Halmand and Arghandab, and from this point along the banks of the Halmand to a considerable distance above Girishk, are scattered the remains of numerous forts and entrenchments, showing the importance that has always attached to this part of the Halmand river. Girishk itself is simply a fort, commanding the Herat road. There is no town near it, but the whole of the Halmand valley is full of small, scattered villages, with gardens, trees, and fields. To the north-west from Girishk, by the Herat road, the country is mountainous, and again towards the north-east, but in a northerly direction it appears quite open and level as far as the eye can see. The only exception is that, on very clear mornings after rain, a few snowy peaks are visible, just showing their tops above the horizon. Captain Beavan found the old position of Girishk fairly correct, and he ascertained the heights of the camping grounds along the route from Kandahar to Girishk by aneroid and boiling point. He concluded his paper with some valuable suggestions on the subject of the formula for barometric heights.

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4. *Afghan War.—The Pishin Valley.*
By Lieutenant St. George C. Gore, *R.E.*

Lieutenant St. George C. Gore (writing from Gulistan, in Pishin) described the Pishin Valley, which is now to be annexed by the British Government. Its extreme length is about 48 miles, and its average width, including the hill ranges on either side, from 25 to 30 miles. Its two sides are formed by the parallel ranges of the Khwaja-Amran on the west, and the Mashalak-Ajiram (or Ghazarband range) on the east; the southern end being shut across by spurs of hilly ground which separate Pishin from Shorawak. The upper end of the Pishin valley is shut in by the high plateau of Toba on the north, and the ridges running between the Kand and Takatu mountains on the east.

The valley of Pishin is a perfectly open, nearly flat alluvial plain, with a very barren aspect owing to the absence of trees, except fruit trees in a few gardens.

Lieutenant Gore described the Khwaja-Amran mountains bounding the Pishin valley on the west, which are but a spur of the Suliman range, the water-parting being continuous and well marked from the Kand Peak along the southern edge of the Toba plateau and thence down the Khwaja-Amran range. He also gave full details respecting the river Lora, which waters the Pishin valley, and its affluents; the irrigation system by means of *karez*; the passes over the mountain ranges; and the inhabitants of the valley.

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5. *Afghan War.—Shorawak Valley and Toba Plateau.* *By* Major Campbell, *R.E.*

Major Campbell described the Shorawak valley and the Toba plateau in Afghanistan. The Shorawak valley had never been visited by Europeans before the recent campaign. It is a narrow strip of flat country lying between the desert on the west and north-west, and a range generally known as the Sarlat Hills to the east. Its total length is about 40 miles, with a width of 10 miles at the northern end; and it is 3,250 feet above the sea. The head of the valley, to the north, is closed in by the southern spurs of the Khwaja-Amran range of mountains, which nearly join the north-western spurs of the Sarlat Hills, only leaving a gap of about a mile through which the Lora river runs into the valley.

The desert, which stretches away westward as far as the Persian frontier, rolls up in the form of sand hills to the edge of the cultivated land of the valley. The Lora river, which waters the valley, runs nearly dry in summer, and its water is always brackish, whence the name of the valley from the Persian words *Shor* (brackish), and *Abak* (scarcity of water). The valley is thickly populated, and crops of wheat and barley are raised. Major Campbell suggested that Shorawak was once a lake, which was gradually silted up by deposits from the Lora, and this seems to account for most of the phenomena. The river, after flowing through the valley, is swallowed up in the sand of the desert.

The Toba table-land is at the north-eastern extremity of the Khwaja-Amran range of mountains. It was visited by Major Campbell last May. The crest of the Khwaja-Amran bifurcates at a short distance north-east of the Khojak Pass, one line running nearly due east, and the other about north-north-east. Between these two crests there is an elevated mountain mass extending eastward until it merges in the general confused mountain system in that direction. This table-land is divided into two portions, called Toba and Tabin; the former on the southern and eastern edge, the latter on the western side. They are separated by a narrow line of hills, running about north-east by east. The general elevation is over 7,000 feet. Major Campbell gave an interesting account of this plateau and of its inhabitants. It will probably form an excellent hill sanatorium for the troops stationed in the Pishin Valley. The climate of the plateau in summer is very pleasant.

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6. *New Routes to Candahar.* *By* Captain T. H. Holdich, *R.E.*

In weighing the capabilities of the various passes now known to exist in the mountain barrier of Western and North-Western India, with the important political and strategical object of selecting the best main route to Candahar, the author commenced by stating his objections to those in use at present. Admitting that Karachi may prove the best base for communication with our frontier posts as they stand at present at Quetta and Pishin, he considered that the direct Son Miani route, connecting the coast with Biela, Khelat, and Quetta, though passing through a friendly country, would be too great a burden to maintain, as it traverses a wild, unproductive, and most unpromising region. The Jacobabad-Bholan route on the western side of the Indus is also open to the periodical danger of inundation by that river (resulting last year in the isolation of Jacobabad itself from Sukkur by thirty-eight miles of water), and to the restriction of its use to cold weather, owing to the painful and disastrous effects of crossing the Kachi desert in the hot season.

The journeys, however, of the native explorers, instructed by Colonel Browne, through the previously unknown district lying between the Quetta-Pishin line and the Sulimani range, have resulted in the accumulation of material sufficient to warrant the march of a column under General Biddulph from Candahar eastwards towards Dera Ghazi Khan, which has been selected as the base on the Indian side on account of its proximity to Mooltan on the Indus Valley Railway, and its avoiding a desert passage to the hills. The object of this march was to investigate the various practicable caravan and other routes said to exist between the Pishin

Valley and Dera Ghazi. Starting from Kushdil Khan, at the eastern end of the Pishin Valley, this expedition reached Bolozai, in the Surkhab valley, by crossing the Suranari Pass, and here were discovered two great rivers, the Zhob and Bhori, radiating eastwards through open valleys, and affording the finest openings for a route to India. The Zhob, which trended too much northwards, was not followed, but apparently would strike the frontier ranges at the Gulère (or Gomul) Pass. The Bhori Valley was reached from Bolozai by following the bed of the Surkhab river by Yusuf Kutch to the Ushtàra Pass (a wide and convenient one), the sandstone hills culminating at Mashkwar in grand and vividly coloured scenery, contrasting strongly with the usually tame aspect of the Candahar region. Thence, from Chimjan through the Bhori Valley to Anumbar, the road recalled the Lombardy plains. Part of the expedition turned southwards at Katz, *viâ* Smalan and Baghao, with the intent of exploring the Thall and Chotiali route; but the main party kept the straight road, following the river to Anumbar, and reached the Chimalang Valley by the Treek Kuram Pass, whence they struck south among winding precipitous ranges to Baladaka, eventually arriving by the Han Pass and Hasni Kot to the valley of Lugari Barkan.

This valley is open to the Kaho Pass by Vitakari, and reaches the Derajat plain about forty miles south of Dera Ghazi. All this road is capable of easily carrying a railway, and as it now is will exist for ever; it could be shortened by not striking south at the Treek Kuram Pass, but keeping eastward and south-eastward on the Karwaddi route *viâ* Rakni to the Fort Monro or Sakki Sarwar Passes, opening opposite Dera Ghazi. The party that followed the Thall and Chotiali route also reached the Lugari Barkan Valley, but no good direct route could be found between Thall and Vitakari, which is a desirable position at the head of the Chachar Pass.

The chief addition to our knowledge from this expedition is that the hitherto unknown region between the Pishin Valley and the Sulimani Range is found to be open, rich, and fertile, with nothing in its physical characters preventing travel across it in almost any direction.

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7. *Afghan War.—Surveys round Kandahar.* *By* Major Rogers, *R.E.*

Captain Malcolm Rogers, R.E. (writing from Kandahar), gave an account of the recent survey operations in Baluchistan and Southern Afghanistan. During the march to Kandahar the work was restricted to a route survey of the immediate line of march; and the careful survey made during the former Afghan war by Lieutenant Durand, R.E., was found to be very correct. Captain Rogers, however, connected his work near Quetta with points on the Khwaja-Amran range of mountains, and thence fixed points on the great plain stretching from the mountains to Kandahar. He climbed the highest hill of the range, whence its name is derived, which is 8,960 feet above the sea.

Between the Khwaja-Amran mountains and Kandahar there is a vast plain, with numerous detached hills and ranges, mostly of limestone. There is little water, and the general appearance is treeless and barren. To the westward this plain is bounded by a vast desert of rolling sand-hills. The river Dori is the only perennial stream in this plain.

Captain Rogers accompanied General Stewart when he advanced from Kandahar to Kalát-i-Ghilzai, and carried on a route survey; but the division followed on the track of the army of 1839, and there was not much to add to former work. The troops advanced up the valley of the Tanak, the river being rapid and muddy in January, and having cut for itself a deep winding channel. There were many villages on both banks. During the stay of the army at the fort of Kalát-i-Ghilzai, the surrounding country was mapped. When the troops returned to Kandahar, arrangements were made for small columns to march back by the valleys of the Arghastán and Arghandab. Thus 50 miles of the courses of these two rivers above Kandahar were surveyed. A trigonometrical survey of the country for 12 miles round Kandahar was also executed; and an expedition was sent into the Khakrez

valley, about 30 miles north of Kandahar. It drains into the river Arghandab, from which it is separated by a range of low hills. The longitude of Kandahar was fixed by electric telegraph.

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8. *On the Orography of the North-Western Frontier of India.* *By* Trelawny Saunders.

The paper divides the mountains into groups, to each of which distinct limits are assigned. The several parts of certain groups are then discussed, for the purpose of assigning definite limits to the nomenclature of each part. The parallelism of the ranges with the axis and base of the mass is next enlarged upon, with a view to expose the fallacious assumption of the prevalence of formidable spurs obstructing lateral communication. Various examples of prolonged lateral communications in the mountains on the north-western frontier of India are cited. In conclusion the southern part of the high land extending along the Arabian Sea and the Persian Gulf from the plain of the Indus to the plain of Mesopotamia is referred to, especially with reference to the proper line of the future railway to India.

The low land along this coast is particularly objected to for a railway, on account of its deadly climate and an atmosphere reeking with intensely hot vapour. A chain of elevated valleys running parallel to the coast is traced by way of Shiraz and Kej as a preferable railway route.

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9. *Imperial Survey of India.* *By* J. O. N. James, *Esq.*, *Deputy-Superintendent of the Surveys of India.*

The object of Mr. James's paper was to sketch out, in a concise manner, the nature of the work in progress and already performed by the Indian Survey Department, and to point out its practical utility. The Imperial Survey of India, up to a late period, consisted of three distinct branches, namely, the Trigonometrical, Topographical, and Revenue Surveys. The Trigonometrical Survey, besides its purely scientific work, furnishes the great basis by principal triangulation for the origin and extension of detail surveys executed by the Topographical and Revenue Branches. Already the whole of India is covered with principal triangulation which, for scientific accuracy, is unsurpassed by any similar undertaking in the world. To the Topographical Branch is assigned the labour of executing geographical surveys of native States and hilly or forest tracts in British territory, usually on a scale of one inch to the mile. Mr. James described the methods adopted in the execution of these topographical surveys, and pointed out the vast amount of geographical information which is collected by the surveyors. During the administration of Sir Henry Thuillier, late Surveyor-General of India (1861 to 1877), an area of not less than 290,000 square miles was surveyed and mapped, including the wildest and least known tracts of India. This enormous area, more than double the size of Great Britain and Ireland, was surveyed in sixteen years at an average cost of 2*l.* the square mile.

The Revenue Survey operations are chiefly confined to open and well cultivated districts in British territory. They furnish complete and accurate records of the area and boundaries of every village and district. They show the extent of waste and cultivated land, the nature of the soil, and the principal features of the country on a scale of four inches to the mile. From these original surveys excellent maps of complete districts are completed on various scales, for general administrative purposes. In some special districts the system of cadastral field surveys has been introduced. During Sir Henry Thuillier's superintendence (from 1847 to 1877) an area of 493,000 square miles was completed on the village survey system on a scale of four inches to the mile, and 12,281 square miles by cadastral measurement on a scale of 16 and 32 inches to the mile; making an aggregate of 505,574 square miles, considerably more than double the area of France. The Revenue Surveys comprise a great portion of Bengal and Assam, all Oudh, part of the North-West and Central Provinces and Bombay, nearly all the Punjab, and all Sind.

This work has not been accomplished without the sacrifice of many valuable lives, and the necessity of facing dangers and hardships of no common kind. The zeal and devotion of the Indian surveyors are beyond all praise; and their work has been and continues to be most valuable. It must, however, be clearly understood that a considerable portion of what has been accomplished by the Topographical Branch of the Department is nothing more than a first survey, rapidly executed, for geographical and general administrative purposes. Hereafter more rigorously accurate and complete surveys will be needed. Meanwhile there is not a single official in India who does not possess maps of the portion of the country included in his jurisdiction, which are suited to every present requirement. The maps issued by the Surveyor-General's Department are also utilised by engineers in the construction of public works, by the foresters for conservancy purposes, by mining companies, planters, holders of estates, and by every branch of the civil and military services for purposes too numerous to detail.

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10. *Three Months in Cyprus.* *By* Samuel Brown, *M.I.C.E.*

Having had charge of certain preliminary surveys undertaken with a view to the improvement of the harbour, inland communications, and sanitary condition of Cyprus, as well as the development of its material resources, the author, during three months of constant travelling and camp life last winter and spring, had opportunities enjoyed by few Englishmen since the occupation in July 1878, of making himself acquainted with the place and people.

After describing first impressions on approaching the southern coast, the bare treeless desert-like aspect of the hills behind Larnaca, the road thence to Nicosia and from Nicosia across the great Mesavoria plain to Famagosta, as they appeared late in the year before the rainy season had set in, the author confesses to the disappointment he shared with other visitors after reading the *couleur de rose* descriptions during the early days of the occupation. First impressions were, however, greatly modified by subsequent experience. About Christmas heavy rain fell, and in a few days the aspect of the country changed. The great corn-growing plains became green, and the moorlands and pastures afforded herbage for large flocks of sheep and goats, while the ground was thickly studded with wild flowers, chiefly narcissus, anemones, cyclamen, and two species of lily. And although the eastern part of the island, including the districts of Larnaca, Nicosia, and Famagosta (*i.e.* those parts best known to visitors) is painfully destitute of trees and shrubs, this does not hold good of other parts. The park-like beauty of portions of the Limasol coast district, the secluded and exquisitely beautiful valleys of Kythrea and Lefka, rival on a small scale for rich sub-tropical vegetation anything that is met with in countries bordering the Mediterranean. The winter climate of the south-west coast is warm and balmy, and probably is hardly surpassed by that of any fashionable health resort. In artistic beauty, too, the fantastic form of the northern range, and the grander masses of Troados with its romantic valleys, may well compare with the scenery of any neighbouring island.

The fruit-producing capacity of Cyprus is almost unlimited, but needs for its development irrigation, better cultivation, and roads for the conveyance of produce to market. A great extension of vine culture is anticipated. Last year the Limasol district alone produced 1,622,500 gallons of wine, against 618,000 during the preceding year, being an increase of 270 per cent. This wonderful advance is accounted for chiefly by the removal of certain vexatious conditions attached to the making of wine, due to the ingenuity of the Turkish tax farmer.

The population, estimated approximately at 200,000, consists probably of about three-fourths Greek Christians and one-fourth Mohammedans. No census has yet been made. Both Turks and Greeks are indolent, unambitious, self-willed, and obstinate; but peaceable, domestic, and fairly honest. Life and property are probably not safer in any part of Her Majesty's dominions than in Cyprus. Education of all classes, clergy and laity, is of the lowest standard. Good elementary secular education should be provided by the State.

In speaking of antiquities, special attention is called to the fine remains of

western mediæval architecture in the churches of Nicosia and Famagosta. These merit a special memoir by a competent archæologist. The fortifications of Famagosta are probably one of the finest and best preserved examples of the military engineering of the fifteenth and sixteenth centuries. A colossal vase of compact limestone, 11′ 6″ diameter, nearly 8 feet in height, with sides 10 inches thick, is seen on the summit of the hill which formed the citadel of the Phœnician city of Amathus. There is a similar vase in the Louvre, also from Cyprus. The author carefully examined vestiges of an ancient canal, which formerly served to connect the salt lake south of Limasol with the sea.

The climate of Cyprus is next described, more especially with regard to the fevers prevalent in some districts. The malarious fever is attributed chiefly to emanations from marshes, which are, however, of limited area. To improve the climate, especially about Famagosta, the marshes should be drained, and the river Pidias embanked in the lower part of its course, and thus prevented from spreading over and converting the plain into a swamp. The necessary works may be carried out at moderate cost, and should prove remunerative by bringing land, now worse than useless, into cultivation.

Agriculture is, with few exceptions, in a very backward and unsatisfactory condition. Attempts at cultivation are only made in the case of the best lands, and these produce but one corn crop every two or three years. The rainfall is often insufficient, and the period at which rain falls, and the quantity, vary within wide limits. During the past ten years there have been but five fairly good harvests. Much of the water needed for the crops is carried off rapidly by torrents to the sea. The remedy for these evils is to store water in tanks, after the Indian native system, and distribute it over the land by canals as needed. This supply of water for irrigation from tanks should be supplemented by artesian wells and an extension of the method which has prevailed in Cyprus from an early age, of collecting water from a series of shallow wells. Water is met with at moderate depths over the greater part of the island. Irrigation, wherever employed (as it now is in many districts on a small scale), is attended with the happiest results. The irrigated lands produce a succession of abundant crops, and their value is at least five times that of land of similar quality not irrigated.

In conclusion, the author calls attention to the fact that no map exists of the island with even an approximation to accuracy, and recommends, first, the completion of the trigonometrical survey which was commenced, but has been suspended; secondly, a geological survey; and thirdly, systematic meteorological observations, the existing data as to rainfall being of the most meagre description.

TUESDAY, AUGUST 26.

The following Papers were read:—

1. *Hydrography, past and present.* *By* Lieutenant G. Temple, *R.N.*
See Reports, p. 229.

2. *Arctic Research.* *By* Commander L. A. Beaumont, *R.N.*

The author holds that the future of Arctic work must depend upon the persevering efforts and reasonable arguments of those who advocate it; and that the revival of interest in Arctic exploration will commence amongst those who are sure to be more influenced by valuable and substantial results as an object, than by the prospect of a brilliant but profitless achievement.

In spite of the unfortunate controversies which followed the return of the late

Arctic Expedition, the discovery of the unknown will never be permanently abandoned, and the Arctic Regions, in common with the rest of the world, will surely be discovered and explored. As regards the alleged risks and dangers, the author asks why they should exercise a deterrent effect any more than the perils and dangers of African or Australian travel. There will always be men ready to go, and in due time there will be sufficient support forthcoming to provide the means. But it is desirable to utilize the experience of the present generation, rather than wait until all experience must be obtained anew.

On the east coast of Greenland and beyond Robeson Strait there is heavy ice similar to that met with by MacClure and Collinson, and afterwards by Meahan and McClintock, along the coast of North America and adjacent islands, and whenever it occurs ship navigation entirely ceases, while the difficulty of sledge travelling is immensely increased. It would seem that in all future work this sort of ice must be reckoned upon; and that no ship will ever get much beyond 82° north. In sledge travelling it is indispensable that land should be near, and that the ice should be fast, and there are few known points where these conditions can be obtained.

Nevertheless, Commander Beaumont contended that there was nothing discouraging in this; nor need the work be confined to the highest latitudes, for where scientific research and a practical school for future explorers are the objects, much important work can be done in all parts of the unknown region. He anticipated a rich harvest of valuable results from the work of the present year. The Swedish Expedition is already a great success, and those who know Captain Markham feel certain that his present cruise will bear good fruit.

The author then addressed himself to the question of which route affords the best promise of geographical discovery, observing that geographical discovery will always embrace much that is valuable in many other branches of science. Franz Joseph Land seems, at first sight, to fulfil the conditions required to ensure success. Here the land extends far to the north, and if any part of the shore could be reached by a ship, a sledging party might certainly attain to the 86th parallel. But the disadvantages of the route are, that it is uncertain whether a vessel could reach the land, while there is no alternative after starting but to succeed or fail. If the main object is not gained, no lesser useful work can be done. The next route, in Commander Beaumont's opinion, now that the North-east passage has been achieved, is the exploration of the land about Cape Britannia, proceeding by way of Smith Sound: that is—the discovery of the northern side of Greenland. He prefers this route to an attempt along the eastern side, because a higher latitude can be reached by Smith Sound; and believes that a vessel might winter on the eastern shore of Robeson Strait, and advance depôts to Repulse Harbour in the autumn. Commander Beaumont, who has seen Cape Britannia, the most northern known point of Greenland, believes that to stand on its highest peak would alone throw much light on Greenland geography. He then submitted calculations, derived from his own experience, of the time that it would take for a sledge party to reach Cape Britannia, and of the nature of the ice; and offered several valuable suggestions for improved appliances in travelling over soft and deep snow.

Commander Beaumont confidently predicts important geographical discoveries, and other useful scientific results for an Arctic Expedition despatched up Smith Sound with Cape Britannia and coasts beyond as its principal goal.

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3. *On the Interior of Greenland: the principal points of Geographical Interest connected with it, and the recent Expeditions for its Exploration.* *By* Dr. H. Rink.

This paper contains a sketch of the presumed physical conditions of the interior of Greenland, as the best and largest existing illustration of the glacial epoch of geologists which has had so much effect upon the surface of modern northern Europe, and the only region where true icebergs can be observed in course of formation. Of this interior very little is actually known, the point reached by the expedition mentioned in the present paper being the farthest hitherto attained. Even of the coast some 600 miles still remain unknown; but, supposing it not to extend

further northwards than is at present supposed, the whole coast line is 3,400 miles, and its area 512,000 square miles, wholly covered with ice, except, perhaps, where some barren highland may penetrate the glacial surface, and constantly engaged in the formation of material for icebergs, which probably take one hundred years to travel from the presumed central water-parting to the heads of the fjords where they fall into the sea, but only at certain points. In one of these ice-fjords the portion of glacier annually pushed in, and representing the annual surplus from an extensive area, has been calculated to constitute a cubical body 900 feet high, two miles long, and two miles broad.

The investigation of the interior of this country, of especial interest to geographers as one in which the whole system of river drainage is represented by a continuous sheet of ice, has since 1875 been taken in hand to some small extent by the Danish Government, which has in 1876–78 annually voted 550*l.* for scientific work there, mainly with the object of completing the coast-maps in connection with the geological survey. In the course of these operations explorations were extended over the border of the inland ice. In 1876 the geologist Steenstrup, with Lieutenant Holm and Mr. Kornerup, travelled over the Julianshaab district, between 60° and 61° N. lat.; in 1877 the investigations were continued by him and Lieutenant Jensen between 61° and 63° N. lat.; and in 1878 the expedition was divided, Jensen, Kornerup, and Mr. Groth exploring the coast between 62° 30′ and 64° 30′ N. lat., and Steenstrup, who has not since been heard from, turning to the more northern regions between 70° and 72° N.

Lieutenant Jensen's party, in July 1878, crossed the inland ice in 62° 30′ N., in the endeavour to penetrate as far as possible into the interior. The object was to reach certain iceless mountain-tops, called Nunataks, emerging in the distance from the surface of the glacier, and which more than a century ago had been ascended by a Danish trader. These were reached after a march of more than forty miles in a straight line across the ice. On the lower of these Nunataks the roughness of the surface of the ice was very great, being traversed by yawning chasms divided by steep and slippery elevations, and cut by watercourses disappearing as cascades into the crevasses. The party consisted of four, one of whom was a Greenlander, drawing three small sledges, and generally tied together by a rope. After many perilous adventures they reached the foot of the hills, the view from the summit of which was obscured for a week by snow-storms and mist. On the weather clearing, a successful ascent was made, the elevation being found to be 5,000 feet. The ice waste of the interior was found to rise very slightly inwards, without visible interruption. In the present year Jensen, Kornerup, and Lieutenant Hammer have been sent on a coast survey between 67° and 68° 30′ N. lat., of which very little is known.

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4. *Indian Marine Surveys.* *By* Clements R. S. Markham, *C.B., F.R.S., President of the Section.*

The Indian Navy created a splendid staff of surveyors, and many admirable marine surveys were executed by them before the abolition of that useful service in 1862. But from that time, during a period of twelve years, all marine surveys on the coasts of India were absolutely stopped. Meanwhile trade increased, more especially the coasting trade, and new ports were opened to facilitate the export of coffee and other products. While the Government utterly neglected the duty of making the approach to Indian coasts and harbours tolerably safe, the urgent need for correct guides to navigation became each year more and more apparent.

These facts were earnestly represented to the authorities both at home and in India in 1871 and succeeding years, and at length the creation of a Marine Survey Department was sanctioned, and Commander A. D. Taylor (late of the Indian Navy) was appointed Superintendent. The work was commenced in October, 1875, but no suitable vessels have yet been supplied, and the work has hitherto been done by boat parties.

Captain Taylor makes annual inspection tours, by which means he has discovered many serious errors in existing charts, and has contributed largely to our knowledge

of what is needed at the various ports around the coasts of India. Lieutenant Jarrad, R.N., conducts the actual surveys; and the construction of charts, the publication of notes to mariners, wreck returns, and lighthouse lists are entrusted to Mr. Carrington, the Chief Civil Assistant. A new steamer, called the *Investigator*, is now being built at Bombay, specially fitted for scientific surveying, and will be ready in 1880. A naturalist forms one of the staff of the Department; and when the new steamer is ready, and fitted with apparatus for deep sea sounding and dredging, systematic scientific investigations will be undertaken. Useful results have been produced by the Department in a wonderfully short time. From the spring of 1875, when Mr. Carrington got his branch into working order, to 1879, as many as eighty charts have been produced, or more than one each month, from which 11,400 copies have been photo-zincographed. Upwards of 15,000 charts have been corrected for new lights and buoys, and 20,000 copies of notices to mariners have been distributed. A very great improvement has also been made in the report of wrecks and casualties. A chart depôt has been established at Calcutta, where some 20,000 charts are shelved and numbered, and considerable sales are now being effected. This is an immense benefit to the merchant shipping in Indian ports, and the Department has also been able to supply H.M.'s ships when charts were urgently needed.

The continued prosperity and efficiency of this useful Department is of the utmost consequence to the shipping and manufacturing interests of nearly all the maritime nations in the world, as well as to the people of India; and it is no less important to geographers who are supplied with accurate hydrographic information, and are thus enabled to obtain a sound knowledge of the physical geography of the Indian coasts.

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5. *The Exploration of the American Isthmus and the Interoceanic Canal of Panama.* *By* Lucien N. B. Wyse, *Lieut.-Commr., French Navy.*

After some general observations upon the long recognised necessity of a connection of the Atlantic and Pacific Oceans through Central America, and a discussion of the various aspects of the subject, the author pointed out, among other connected erroneous conclusions, a frequent error of opinion as to the practicability of a canal in places where the sources of two rivers on opposite water-partings nearly touch each other, and gave an account from personal experience of the natural difficulties in the way of the explorer in this region. The badness of the climate, however, except in marshy places on the coast, such as Greytown, he believes to have been grossly exaggerated, Panama being considered by him to be the most healthy of inter-tropical towns. There, the waters descend rapidly from great heights; the width of the Isthmus not exceeding 37 miles, and the water-parting being only 10 miles distant. In Nicaragua, however, the physical contour is very different, the elevation of the lake being so slight that the San Juan flowing from it has only a fall of 107 feet in 124 miles, the least rise causing a flood, with marshes extending for 74 miles. On leaving the hill region, the river breaks up into a countless net-work of streams, forming an immense marsh of hundreds of square miles, with proportionately bad climatic conditions. Darien, hitherto considered most unhealthy, has been found by the American expeditions to be nothing of the kind, subject to simple medical precautions. From a hygienic point of view, therefore, Nicaragua is the worst of the three great divisions of routes; and, though all are productive in wood suited for hydraulic purposes, Darien is the most so.

As to the supply of labour, the population is scanty and indolent throughout, though more numerous at Panama. The Indian will not bear regular work; he is timid, and will give way to the spread of civilisation. The chief supply must be from Asia, but negroes will be useful in cutting roads, at which they are very expert; and they may be bought for purposes of liberation at a cheap rate by law of the Spanish Antilles and Brazil, their freedom being made the ultimate reward of their labour.

Of the routes proposed, that of Tehuantepec is the first from the north. Capt. Shufeldt, of the U.S. Navy, after examining the river Coatzacoalcos, found it at a

distance of 120 miles from the great oceans to be small and shallow, necessitating 144 miles of canal and 140 locks. It has no port on the Pacific, and not a good one on the Atlantic side.

The Honduras route is no better, from the extent of its mountainous tract and the distance (93 miles) between the two oceans.

In Nicaragua the mountains disappear, and the lake is only 36 feet above sea level, but a canal would require projecting jetties at each end, especially on the Atlantic side. The badness of the climatic conditions has been above mentioned, and dredging to keep down the deposits of mud and sand would require to be unceasingly carried on.

Of the Darien routes, that by the Atrato is very attractive. Large steamers can ascend it for 156 miles, and it has a wide delta, the most favourable commencement for a canal being at the mouth of the Uraba. Obstacles to its navigation require, however, to be removed. The Tuyra has a less volume of water, but its mouth is very suited for a great international harbour, the climate being healthy and anchorage good. Extensive surveys of these routes have been made, that by Commander Selfridge being the most conspicuous. The Isthmus is narrowest here between the Atlantic and the navigable waters of the Bayano, being only 30 miles wide, but the mountains are narrow and very precipitous. Selfridge's proposed canal follows the Atrato and Napipi, passes the Cordillera by a tunnel, and ends in the bay of Cupica; it obtained the second place at the recent Congress. The lecturer's own Darien expedition of 1876–77 was severely tried by the death of Captain Bixio, the Engineer Brooks, and Musso. Engineering explorations were, however, continued on the Cué and Caquiri rivers; the plateau of Cana was explored as far as Tiati, where an important discovery of a low valley was made. The work was connected with that of the Americans, and a canal planned, which, starting from the bay of San Miguel, was projected to fall into the Atrato. Three hundred and sixty miles of forest and river bank were levelled during this survey. An alternative route was to follow the Tuyra to below the island of Piriaque, join the Chucunaque, utilise the Tupica valley, and passing to the south-east of the Peak of Gandi, reach the Atlantic by the valleys of Tola and the Acanti. In the following year the Bayano was explored, and the line from San Miguel to Acanti determined. The line by Gandi has great advantages; its tunnel is long, but the rock is not hard, and the space is short between the Pacific and the confluence of the Chucunaque and Tuyra. The total cost would not greatly exceed 375,000*l*.

The Panama route, selected almost unanimously at the recent International Congress at Paris, with M. Lesseps as President, is the only one on which a level uncovered canal is possible. It requires a cutting of 262 feet in height, therefore a tunnel is more economical. This would be from $5\frac{1}{2}$ to $9\frac{1}{2}$ miles long, *i.e.*, not longer than the St. Gothard. Volcanoes are extinct or dormant on this line, and no earthquakes are felt.

The route is from Panama to the Bay of Colon by way of the valleys of Chagres and the Rio Grande, and practically follows a road which has been in use since 1532. The elevations of the rail already existing are not great, but the sinuosities are frequent and curves sharp, and the rock to be penetrated in tunnelling is hard. But this route has the advantage of being short, on one level, and near a railway, with consequent facilities of transport; of not requiring delicate works rendering constant repair necessary; and of possessing on the Atlantic side a perfect port in the Bay of Limon, and on the Pacific one not requiring important works, and with a generally calm sea. The tunnel required is short, and can even be dispensed with if absolutely necessary; if made, there is a possibility of multiplying wells for its perforation. Although not geographically connected with this project, it may be observed that a convention has been agreed upon between the lecturer and the railroad company, permitting and aiding the proposed canal. The cost of this plan is estimated at 32,500,000*l*.

6. *On Geographical Studies and Works in Italy.* *By* Professor G. Dalla Vedova.

In Italy, the aids to Geographical knowledge may be thus divided:—

State Undertakings.—The general topographical survey of the kingdom, commenced at the end of 1861, under the general staff of the Italian army, and subsequently carried on by a special office, the Royal Military Topographical Institute at Florence. In 1873, the ex-kingdom of the Two Sicilies was completely triangulated, with other partially geodetic works elsewhere; and since that time the general triangulation of Italy has been undertaken, commencing with Piedmont, with other topographical works to be utilised in the preparation of a map of Italy on the scale of 1 : 100·000, though frequently themselves on a much larger scale. In the present year, 1st and 2nd class surveys are being executed in Piedmont, Lombardy, from Leghorn to Civita Vecchia, in Sardinia, and elsewhere, and are expected to be completed in three years. Operations have also been conducted in aid of the determination of the European level. The Institute also published in 1878 a complete map in photolithography of the province of Naples and Sicily, 174 sheets, scale 1 : 50·000, with elevation in contour lines of 10-metre intervals. Work has also been executed towards the publication of a large map of Italy in photogravure, by Avet's process, to be completed in 277 sheets, scale 1 : 100·000. Twelve sheets of this have been completed in proof.

As to Hydrographic Surveys, under the Minister of Marine, the whole Adriatic coast is completed, with extension in 1877 to Calabria and Sicily, and in 1878 to North Sardinia. Sixteen sheets (with many others provisionally) have been published of a coast map, scale 1 : 100·000.

The Minister of Public Works has in hand the river hydrography, high roads, and railways, on which memoirs are published in the 'Hydrographic Bulletin.' He presented a general account to the Paris Exposition.

The Minister of Agriculture and Commerce, apart from economical statistics, undertakes Meteorology, having a council and thirty-two observatories in his department, and also a geological committee (with Commissioner Felice Giordano as president). The 'Italian Statistical Annual,' under this minister, edited by Commissioner Luigi Bodio, contains condensed results of official information on internal geography and statistics.

In all the schools, geography forms part of the curriculum, though in unequal degrees. It is relatively larger in the elementary, very limited in the lower, and entirely insufficient in the higher classical schools. There are special teachers in only seven of the twenty-three State and private University Institutions, viz., at Bologna, Florence, Naples, Padua, Pavia, Rome, and Turin, and in all these the time and course of instruction devoted to geography are inadequate.

As to State aid in explorations by foreigners, although never organising such expeditions, Italy has always been ready to contribute substantial and moral support for the advantage of science or the benefit of her subjects.

Private Institutions.—Chief of these is the Italian Geographical Society, founded at Florence in 1867 by Commander Cristoforo Negri, who continued President until 1871, when the Society was transferred to Rome. He was succeeded by Commander Cesare Correnti, who held office until January last, when Don Onorato Caetani, Prince of Teano, was elected. The Society now has over 1,400 Fellows, and publishes an 'Annual Bulletin' of 800 pages, with twelve maps, of which 15 vols. had appeared in 1878. It has also published a volume of 'Memoirs' (1878), one of 'Biographical and Bibliographical Studies on Italian Geography,' and another on the 'Physical and Political Geography of Italy' (1875). It has promoted or subsidised various expeditions to the Bogos country, Abyssinia, New Guinea, Morocco, &c. It delivers lectures, gold medals (the last two to D'Albertis and Savorgnan di Brazza), and two pecuniary awards, endowed by the present King and Commissioner Canevaro.

The Turin Geographical Club, founded some years before the Society by Professor C. Peroglio, and of which Signor Guido Cora is now President, has issued some few publications, but is not of any considerable size.

The Italian Alpine Club, with its centre at Turin, presided over by Comman-

der Q. Sella, is now extended all over the kingdom by local sections, chiefly owing to the exertions of Mr. R. E. Budden. It publishes a Bulletin.

The section for Commercial Geography of the Geographical Society, originated by Count Telfener, has not as yet found any definite object.

The Milanese Society for African Commercial Exploration, founded in 1878, with Commander Negri as honorary, and Commander C. Erba as acting President, has already started an expedition under Dr. Matteucci, and has invited Piaggia to undertake another, for pearl explorations on the Gualima.

Of Geographical periodicals, Italy has 'L'Esploratore' (Milan), 'Cosmos,' edited by Guido Cora at Turin, the 'Geological Bulletin,' 'Consular Bulletin,' and the 'Giro del Mondo' (Milan). Of other publications, the account by Professor Giglioli of the 'Voyage of the Magenta,' and the first volume of the account of the 'Travels on the Blue Nile,' by the Missionary Beltrame, are specialised.

In Cartography, the chief progress has been made in scholastic maps; a large relief map of Italy, by Cherubini, being the best, though Guido Cora is preparing a globe and set of wall-maps of considerable excellence.

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7. *Italian Explorers in New Guinea.* By Professor Giglioli.

Much scientific work in New Guinea has been done by Italian explorers, while a very great deal still remains to be done, the high chain of mountains running through the length of this great island being yet quite unknown. Professor Giglioli, of Florence, in this paper, gave some account of the labours of Italians in this field of research. The first Italian who ever visited New Guinea was the Count Carlo Vidua di Conzano, in 1830, who went to Triton Bay in a Dutch vessel. In 1869–70 Colonel G. di Lenna, a distinguished military officer, and G. Emilio Cerruti reached the south-west coast of Papua, but were treacherously attacked by the natives on the north side of MacCluer Bay. A survey was made by them of Galewo Straits. Dr. Odoardo Beccari and L. M. D'Albertis, in 1872, reached an island in Galewo Straits, whence they made excursions to the mainland of New Guinea. They afterwards explored the Arfak mountains, the home of the birds of paradise; but D'Albertis was attacked with fever and obliged to retire to Sydney. Meanwhile Beccari visited the Aru and Kei Islands. In New Guinea the travellers made very important botanical and zoological collections, including a new bird of paradise. In 1875 Dr. Beccari started on his second visit to New Guinea, with generous aid from the town and provincial councils of Genoa. Hiring a schooner at Amboyna, he landed at Dorei-Ham, ascended Mount Morait to a height of 3,500 feet, and obtained a view of the largest river in the northern peninsula of New Guinea. He afterwards reached its banks, and found that it flowed from the Arfak mountains to the north-west coast. Beccari then explored the whole curve of the wide Geelvink Bay, and visited the islands in it. He also again visited the Arfak mountains, attaining a height of 7,000 feet, and ascertained that the highest peaks reached 9,500 feet. He returned with immense natural history collections. Signor Albertis, after a long stay in Australia, set out on a second expedition to New Guinea in 1875, intending to visit the south coast, and to penetrate into the interior by one of the large rivers. He was accompanied by a young Genoese, named Tommasinelli. They reached Yule Island, whence they made several excursions; but afterwards endured much from sickness and want of food, and Tommasinelli was obliged to return home. After again visiting Australia, D'Albertis joined the English missionaries, Macfarlane and Stone, to make an expedition up the unknown Fly river. That river was ascended for 150 miles. Returning to Sydney, he met with liberal support, and was provided with a steam launch. In this small craft he re-entered the Fly river in May 1876, and ascended it for about 500 miles, planting his flag nearly in the centre of New Guinea. In 1877 he once more entered the Fly river, but the natives had become hostile, and after encountering great dangers he reached Mount Ernest Island in Torres Straits, on January 1, 1878, having been deserted by all his crew, except the English engineer and a boy. He made very large botanical, zoological, and ethnological collections, which are of great value. The Italian explorers in New Guinea have brought home about 5,000 specimens of plants, nearly 100,000 of animals, of which 10,000 birds and 80,000 insects have been deposited by Beccari and D'Albertis in the museums of Genoa and Florence.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

PRESIDENT OF THE SECTION—G. SHAW LEFEVRE, M.P., Pres. Statistical Society.

[For Mr. Lefevre's address see p. 479.]

THURSDAY, AUGUST 21, 1879.

The following Papers and Report were read:

1. *The Scientific Societies in relation to the Advancement of Science in the United Kingdom. By* Professor LEONE LEVI, *F.S.A., F.S.S., F.R.G.S., Doctor of Economic Science, and of Lincoln's Inn, Barrister-at-Law.*

At the meeting of the British Association at Norwich in 1868, I had the honour of laying before this Section a paper on the progress of learned societies, illustrative of the advancement of science in the United Kingdom. The importance of the subject, and the renewed effort to rear a building in the metropolis for several scientific societies, now but insufficiently accommodated, have induced me to submit to this Section another communication on the number and resources of such scientific societies at this moment, and therewith on the improved condition of science.

The relation of our learned societies to scientific progress is close and intimate. Men of science are not now, as they once were, secluded from human society; they live in our crowded cities; they frequent our centres of manufacture and commerce; they cluster together; they unite for scientific researches; they pursue their studies in the open day. No air of mystery, no jealousy or secrecy, surrounds their movements. The discoveries they make find a ready vent at our scientific societies. A communication at the Royal Society constitutes an era in physical science. It was at the Society of Antiquaries that Dr. Schliemann laid bare the wonders of Homeric Troy; it was at the Royal Geographical Society that Livingstone related his discoveries in Africa, and Captain Sir George Nares his adventures in the Arctic exploration; it was at the Institute of Civil Engineers that Mr. Bidder expounded the system of mental calculation, in which he was so distinguished; and it was at the Society of Arts that Professor Bell explained his discovery of the telephone, and Mr. Priestley endeavoured to popularise the principles of the electric light. Happy moments that Newton and Faraday, and the host of past and present workers on the golden soil of science and philosophy, were and are able to spend in the rooms of our scientific societies! Read their transactions for any one year, and see how brimfull they are of precious seeds of human advancement!

We have reason to be thankful for the advancement of science. If by science

we mean a clear and certain knowledge of anything founded on self-evident principles or demonstration, little progress, I fear, can be expected, because necessary or mathematical truths are limited in number, and because we live under conditions that we can but seldom have any clear or certain notice of things capable of producing absolute conviction. But if we use the word 'science' for a formed system of any branch of knowledge, for knowledge generalised, systematised, and verified, comprehending the doctrine, reason, and theory of the thing, with or without any immediate application of it to any use or office of life, then we may say science is making immense progress. We certainly know more than ever we did of the physical property of things, and their operations. Many things which were formerly known but vaguely and loosely are now known more fully and completely. Much of what was, at best, a guess or a supposition, is now founded on experimental knowledge. There has been both a large accumulation of facts and a clear discerning of their relation one to another. We have fathomed Nature more closely, discovered more of her powers, and utilised more of her forces. What problems in mathematics and algebra have been solved, and how happily have their principles been applied to the science of life—to mechanics, navigation, and astronomy! What advance in medical science, especially in hygiene, pathology, and surgery! What advancement in scientific instruments, as revealed in our late exhibition at South Kensington! What revolutions in our knowledge of geology, mineralogy, and biology! And how much have the philosophical sciences, especially of politics and social economy, become extended and methodised! Science has truly made, and is making, constant progress, and we have abundant proof of it in the multiplication of our scientific societies, in the greater reverence paid to science, and in the greater activities of its votaries.

In the seventeenth century there were only two scientific societies in the United Kingdom—the Royal Society and the Society of Antiquaries. In olden time the Universities were the sole centres and propagators of science. The eighteenth century saw the establishment of the Royal Society of Edinburgh, the Royal Irish Academy, the Linnæan Society, the Royal Institution, and the Society of Arts. But the nineteenth century has been very prolific in the formation of scientific societies. As each science expanded, its cultivators became more numerous, and they soon saw the advantage of uniting in their labours, publishing their transactions, and forming themselves into groups and distinct societies. At this present moment London, the metropolis of science, possesses upwards of forty to fifty scientific societies, and the calendar for the season exhibits an amount of activity quite unknown in former periods. And it is the more remarkable in this age, often described as wholly given to the ignoble occupation of money-making, that all the labour thus performed by men of science in England, Scotland, and Ireland, year by year, is the spontaneous offering of time and learning of men, in most cases far from affluent, to the great cause of human and scientific progress.

First and foremost among our scientific societies are the three Royal Societies, one in England, one in Scotland, and one in Ireland. Though the primary objects of the Royal Society of London are the promotion of mathematical and physical science, it has for a considerable time achieved the distinction of having among its members some of the most distinguished men from all branches of science. The Royal Society differs from the French Institute and other foreign academies principally in the fact that it is not divided, like them, into sections, and its members are not paid by the State. The Institute of France, in its five divisions—the Académie Française, Académie des Inscriptions et Belles Lettres, des Sciences, des Beaux Arts, and Sciences Morales et Politiques—has 226 members, 36 free academicians, 32 foreign members, and 236 foreign correspondents. The Royal Prussian Academy of Science, in its two divisions—the Physico-Mathematical and Philosophic-Historical—has 44 ordinary members, 16 foreign members, 11 honorary members, and 175 corresponding members. Other Royal Academies have fewer members. The Imperial Academy of Science of St. Petersburg is composed of 15 professors, besides the president and directors. The Royal Academy of Science of Turin consists of 40 members resident in Turin, 20 non-resident, and 20 foreign members. The Royal Society of London has now 549 members. Since the passing of the law, in 1847,

restricting the yearly elections to 15 members, the number of Fellows has gradually become smaller. The Royal Society of Edinburgh has now 428 members, and the Royal Irish Academy 328 members, making altogether 1,305 members.

In comparison with the return given in 1868, the number of members of the three leading Societies was as follows, showing a decrease of 4 per cent.:—

Date of Foundation	Societies	Number of Members 1857	Number of Members 1878	Per cent. Increase	Per cent. Decrease
1662	Royal Society	651	549	—	15
1783	Royal Society of Edinburgh . . .	350	428	22	—
1790	Royal Irish Academy	358	328	—	8
		1,359	1,305	—	3·97

For the promotion of the physical and mathematical sciences, including all that is classed under the various branches of natural philosophy—all, in fact, that we know of the material universe—we have at least nine societies, having together some 5,300 members. We have, first, the Physical Society, holding its meetings at South Kensington, with 270 members. Next, the Chemical Society, for the study of the laws which regulate the relation of the elements with one another, and to which their compounds are subject in their mutual action, and of the properties of the elements and of the compounds formed by their union. The Chemical Society has made considerable progress within the last ten years. It now consists of 1,015 members. Geology is another branch of physical science, as the science of the earth, including all the sciences that treat of the constitution and distribution of the inorganic matter of the earth, as well as those which describe the living beings that inhabit it. The Geological Society has 1,336 members. Astronomy is a mathematical as well as a physical society. It is physical in so far as it is concerned with the nature of the power or forces that carry on the heavenly motions, the laws that they observe, and the calculation of the motions from a knowledge of their laws. The Royal Astronomical Society has now 631 members. Meteorology, which treats of the phenomena and modifications of the atmosphere as regards weather, climate, &c., is another physical science. The Meteorological Society of England has 425 members; the Scottish Meteorological Society 658 members. For mathematics, as the science which has for its subject-matter the properties of magnitude and number, we have the London Mathematical Society, with 147 members. And in connection with the science of numbers, applicable alike to all that relates to the physical, economical, moral, or intellectual condition of mankind, we have the Statistical Society. Some doubt has been expressed as to whether statistics be more an art than a science. Statistics are truly fit instruments in the hand of men of science. In chemistry and medicine, in astronomy and meteorology, in population and education, in commerce and finance, the scientific collection of facts or the numerical expression of experience is of the greatest utility, and there is doubtless much art in the using of statistics. In the words of Lord Derby in his opening address to this Section at Cheltenham, its characteristics as a scientific method of observation are, 'that it proceeds wholly by the accumulation and comparison of registered facts; that from those facts alone, properly classified, it seeks to educe general principles; and that it rejects all *à priori* reasoning, employing hypothesis, if at all, only in a tentative manner and subject to future verification.' Dr. Guy, in his paper on the meaning of the term 'statistics,' asserted the claims of Statistics as a science on the ground of its exact classification and nomenclature, of its numerical method, of its analysis in tabular forms, of its power of eliminating disturbing elements, and establishing numerical equalities. The province of the

Statistical Society is certainly not only to bring together those facts which are calculated to illustrate the condition and prospects of society, but to show how, by the scientific collocation and classification of facts, the student may draw results and lessons of the highest importance, especially to the economist and politician. The Statistical Society numbers now 746 members; there is also an active Statistical Society in Manchester, with 178 members, making in all 924 members.[1] Altogether the Societies for the propagation of physical and mathematical sciences exhibit the satisfactory increase of 49 per cent. in their membership.

Physical and Mathematical Sciences.

Date of Foundation	Societies	Number of Members 1867	Number of Members 1878	Per cent. Increase	Per cent. Decrease
1878	Physical Society	—	270	—	—
1841	Chemical Society	518	1,015	95	—
1820	Royal Astronomical Society . . .	528	631	19	—
1807	Geological Society	1,100	1,336	21	—
1850	British Meteorological Society . .	306	425	38	—
	Scottish Meteorological Society . .	520	658	26	—
1865	London Mathematical Society . .	111	147	32	—
1834	Statistical Society	371	746	101	—
1834	Manchester Statistical Society . .	162	178	9	—
		3,616	5,406	49	—

Another group of sciences which numbers many cultivators is that connected with natural history. First among these is Anthropology, or the natural history of mankind, for which a special society exists, with 462 members. There was formerly an Ethnological Society of sufficient number, but that is now amalgamated with the Anthropological. The Psychological Society, for the investigation of the forces by which the human mechanism is directed, has 117 members. The biological sciences are numerous, dealing as they do with all the phenomena manifested by living matter. We have the Linnæan Society, devoted alike to botany and zoology, with 668 members; the Entomological, for the study of insect life, with 238 members. Most important, however, are the Royal Agricultural Society with 6,797 members, the Royal Horticultural Society with 2,398 members, the Royal Botanic Society with 2,504 members, and the Royal Zoological Society with 3,350 members. Their aim doubtless is to unite science with practice, and thus in some sense they must be said to belong to the group of applied science; but in truth their exhibitions and gardens are museums of the greatest value for the study of the vegetable productions of the globe, and for the advancement of zoology and animal physiology.

[1] There is also a Statistical and Social Enquiry Society of Ireland, but the number of members is not published.

Biology and Natural History.

Date of Foundation	Societies	Number of Members 1867	Number of Members 1878	Per cent. Increase	Per cent. Decrease
1863	Anthropological Society	1,031	462	—	123
1875	Psychological Society	—	117	—	—
1788	Linnæan Society	482	668	39	—
1833	Entomological Society	208	238	14	—
1839	Royal Agricultural Society . . .	5,525	6,797	21	—
1804	Royal Horticultural Society . . .	3,595	2,398	—	33
1836	Royal Botanic Society	2,422	2,504	3	—
1826	Royal Zoological Society . . .	2,923	3,350	14	—
		16,186	16,534	2	—

We might imagine that we have well exhausted the sciences connected with matter and life when we have reviewed the objects of the societies devoted respectively to physical and biological sciences. But there are more. Archæology, which not only embraces whatever pertains to the early history of any nation, but concerns itself with the fossil remains of man, counts several important societies. They are the Society of Antiquaries, with about 600 members, the British Archæological Institute, with 492 members, and the Royal Archæological Institute, with 614 members, besides a number of local societies. Geography is no longer content with a mere description of places and geographical discoveries, but treats of astronomy and meteorology. Professor Duncan's lecture on 'Mainland Masses,' Mr. Wallace's lecture on the 'Comparative Antiquity of Continents as indicated by the Distribution of Living and Extinct Animals,' and Professor Geikie's lecture on 'Geographical Evolution,' have placed the science of geography on a higher platform than it was wont to occupy. The Royal Geographical Society is one of our most popular and most useful societies, and counts the goodly number of 3,332 members. The French Société de la Géographie has 1,563 members, and the Società Geografica Italiana counts 1,583 members.

Archæology and Geography.

Date of Foundation	Societies	Number of Members 1867	Number of Members 1878	Per cent. Increase	Per cent. Decrease
1572	Society of Antiquaries	651	600	—	7
1864	British Archæological Association . .	480	492	2	—
1843	Royal Archæological Institution . .	697	614	—	11
1830	Royal Geographical Society . . .	2,102	3,332	58	—
		3,930	5,038	28	—

Another group of scientific societies deals with science in its manifold applications. They encourage science in relation to special arts and occupations. To this group belongs the Institute of Civil Engineers, for the general advancement of mechanical science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a civil engineer, with 3,315 members. The Institute of Mechanical Engineers has 1,146 members;

the Society of Engineers, 355 members; the Iron and Steel Institute, 900 members; besides the Society of Naval Architects and Telegraph Engineers. More allied to art than to science is the Royal Institute of British Architects, for the advancement of civil architecture, which has now 820 fellows and associates. There is the Society of Arts, ever active, promoting inventions, discoveries, and other matters connected with the arts, manufactures, and commerce, having also an Indian section, an African section, and a Chemical section for the discussion of subjects connected with practical chemistry and its application to the arts and manufactures. The society has now 3,686 members. The Pharmaceutical Society, for the purpose of advancing chemistry and pharmacy, has 4,536 members and associates; the Institute of Actuaries, for the extension and improvement of the data and methods of the science which has its origin in the application of the Doctrine of Probabilities to the affairs of life, and from which the practice of life insurance and the valuation of reversionary interests, deferred annuities, &c., derive their principles of operation. The Institute has now 362 fellows and associates. And of the same character are the Clinical Society, with 336 members; the Obstetrical Society, with 738 members; the Pathological Society, with 601 members; and the Royal Medical and Chirurgical Society, with 666 members.

Applied Sciences.

Date of Foundation	Societies	Number of Members 1867	Number of Members 1878	Per cent. Increase	Per cent. Decrease
1753	Society of Arts	3,278	3,686	12	—
1818	Institute of Civil Engineers	1,698	3,315	95	—
	Institute of Mechanical Engineers	572	1,146	100	—
1856	Society of Engineers	483	355	—	26
1841	Pharmaceutical Society	2,500	4,536	81	—
	Clinical Society	200	336	68	—
	Obstetrical Society	600	738	23	—
	Pathological Society	400	601	50	—
	Royal Medical and Chirurgical Society	641	666	3	—
1834	Royal Institute of British Architects	623	821	31	—
1831	Royal United Service Institution	3,283	4,485	36	—
1847	Institute of Actuaries	228	362	58	—
1877	Institute of Chemistry	—	—	—	—
	Iron and Steel Institute	—	900	—	—
		14,506	21,947	51	—

Besides these there are many scientific societies of a miscellaneous character, such as the Microscopical; the Philological, for the investigation of the structure, the affinities, and the history of languages; the Numismatic; the Asiatic, with 320 members; the Areonautic, with 81 members; the Royal Institution, with 544 members; the London Institution; above all, the British Association for the Advancement of Science, with 3,622 members, and the National Association for the Promotion of Social Science, with about 700 corporate members, composed partly of members already belonging to one or other of the scientific societies, and partly of persons interested in scientific inquiries, though not themselves engaged in the same. We should add also the Victoria Institute, or Philosophical Society of Great Britain, whose objects are to investigate fully and impartially the more important questions of Philosophy and Science; but more especially those that bear upon the great truths of Holy Scripture, *with the view of reconciling any apparent discrepancy between Christianity and Science*; and also to consider the mutual bearings of the various scientific conclusions arrived at in the several distinct branches into which science is now divided, in order to get rid of contradictions

and conflicting hypotheses, and thus promote the real advancement of true science. This Society, now in the thirteenth year of its existence, counts 744 members.

The numerical progress of the scientific societies during the last forty years has been by no means uniform. In some cases a law is in force for the very purpose of restricting the membership. Thus the Royal Society, which in 1846 had 841 fellows, in 1878 had only 549 fellows. The Society of Antiquaries, under a similar law, had 867 fellows in 1831, and in 1878 only 600. Other societies, however, have no limit to their membership, and are capable of great expansion. The danger, indeed, is that in the eagerness to increase their number due care may not be taken to elect only persons sufficiently conversant with the different sciences. There has always existed considerable difference in the character of several of our scientific societies. In some cases they consist exclusively of men of science; in others they comprise many simply interested in the progress of certain sciences; in others, again, they are purely composed of professional men. The Society of Arts, the Royal Geographical Society, the Royal Botanic Society, and the like, are mixed societies, the scientific element being represented in them in more or less proportion. The Institute of Civil Engineers, the Pharmaceutical Society, are composed of professional men. In the interest of the advancement of science, it is undesirable to close the door of entrance too tightly to these societies, and thus lose the means which a large membership places at their disposal for increasing usefulness. I venture to suggest that fellowship in such societies, and the honour of using their initials, should always be reserved for men of science; but that an unlimited number be admitted as members or associates.

Taken at four intervals of ten years, the number of members of the principal societies was as follows:—

Year	Royal Society	Chemical Society	Geological Society	Meteorological Society	Royal Astronomical Society	Statistical Society	Institute of Actuaries	Linnæan Society
1848	812	224	899	—	344	412	—	—
1858	706	277	872	—	436	359	129	—
1868	600	518	1,204	341	528	387	225	535
1878	549	937	1,336	480	631	746	362	668
Per cent. of increase 1848–1878	32	318	48	—	83	81	—	—

Year	Royal Agricultural Society	Society of Antiquaries	Royal Archæological Institute	Royal Geographical Society	Society of Arts	Institute of Civil Engineers	Institute of Mechanical Engineers	United Service Institution
1848	6,335	584	1,039	627	644	626	189	3,947
1858	5,146	635	—	1,039	1,909	857	341	3,246
1868	5,446	622	686	2,102	3,134	1,694	825	3,812
1878	6,797	600	492	3,333	3,686	3,315	1,140	4,484
Per cent. of increase 1848–1878	7	2	52	431	472	429	503	13

Assuming that these societies fairly represent the number of persons in the United Kingdom conversant with and interested in the respective branches of science, the following proportion of each to one million of the population is interesting:—

	Members of Scientific Societies Per 1,000,000 inhabitants	
	1848	1878
Members of Royal Society, London . .	29	16
„ Royal Astronomical Society .	12	18
„ Chemical Society . . .	18	27
„ Geological Society . . .	32	39
„ Royal Agricultural Society .	227	201
„ Royal Geographical Society .	22	98
„ Statistical Society . . .	15	22
„ Engineers, Civil . . .	22	98
„ Engineers, Mechanical . .	6	33
„ Society of Arts . . .	23	109

Altogether, including local scientific societies (see Appendix), the number of members of scientific societies of the United Kingdom is about 60,000. From this number, however, we must deduct at least ten per cent., representing those belonging to several societies—leaving about 54,000 individual members. But even that can scarcely be considered as representing men of science. Probably the half may give us more approximately the number, say about 25,000 persons, having any recognised status in the world of science, or actually engaged in the pursuit of the same in the British Isles.

The income of our scientific societies ordinarily arises from annual subscriptions, or life subscriptions, of members, and from the proceeds of any funded property.[1] The expenditure consists of house rent, salaries, including sometimes secretary and editor, cost of publications and miscellanies. The Royal Society, the Society of Antiquaries, the Linnæan, the Royal Astronomical, the Geological, and the Chemical are provided with rooms at Burlington House by her Majesty's Government. The Royal Geographical Society receives 500*l.* a year subvention towards house rent for the purpose of a public exhibition of their maps and charts. Other societies are but indifferently located, and their house rent constitutes an appreciable proportion of their expenditure. Dr. Siemens, the eminent president of the Iron and Steel Institute, has offered the munificent sum of 10,000*l.* towards the erection of a building suitable for the accommodation of the various societies representing applied science in the metropolis. We trust several societies may see their way to combine for such a purpose, and it would not be too much to expect that her Majesty's Government may, if applied to, be willing to grant at least a site for such a building.

The funds of many scientific societies are far from abundant. A few have a certain amount of stock, but several scarcely succeed in maintaining a perfect equilibrium in their receipts and expenditure. Those societies which hold exhibitions, whether permanent or periodical, are committed to operations not uniformly successful and profitable. The activity and usefulness of the societies may best be tested by the promptitude, character, and extent of their publications. The principal societies publish both journal and transactions. The Society of Arts publishes its Journal weekly, the Royal Geographical monthly, and other societies quarterly. In some cases, however, as in the Society of Antiquaries, the publications appear at long intervals. Some societies publish only mutilated fragments

[1] The Royal Society of London possesses two estates in Lincolnshire and Acton, and upwards of 80,000*l.* in different stocks. The Society of Antiquaries possesses 12,000*l.* stock; the Royal Institution, 33,178*l.*; Royal Geographical Society, 15,469*l.*; the United Service Institution, 18,750*l.*; Statistical Society, 2,000*l.*; Institute of Civil Engineers, 41,500*l.*; Society of Arts, 16,992*l.*; Pharmaceutical Society of Great Britain, 40,805*l.*; Medical and Chirurgical, 3,224*l.*; Royal Agricultural Society, 25,340*l.*

of their communications; others publish them in full, together with the discussion which ensued after the papers were read. For non-resident and busy members the full and early publication of memoirs is of the utmost importance.

It is not to be desired that our scientific societies should be subsidised by the State, but the claim of science to State assistance has been fully recognised, and we may well demand that whatever amount is so devoted be fairly distributed among all the branches of science. In the case of house accommodation it is difficult to see on what ground many of our best and most useful societies are excluded from the boon of free rental. When recently, on the recommendation of the Royal Commission on Scientific Instruction, the State resolved to vote 4,000*l.* annually to aid research, the societies whose presidents were to be taken in consultation were named as the Royal Societies of London and Edinburgh and the Royal Irish Academy, the Royal Astronomical, the Mathematical, Chemical, Linnæan, Zoological, Geological, and Physical Societies, the Institutes of Civil Engineers and Mechanical Engineers, the General Council of Medical Education, the Royal Colleges of Physicians and Surgeons, and the British Association. Several important societies were thereby not recognised.

The amount voted by the State yearly for education, science, and art appears large, and constitutes a somewhat greater percentage on the total national expenditure than in former years, as may be seen from the following figures :—

Year	Total Expenditure	Expenditure for Education, Science, and Art	Per Cent.
	£	£	£
1835	45,669,000	135,000	0·29
1845	48,075,000	300,000	0·62
1855	65,692,000	832,000	1·26
1865	66,462,000	1,361,000	2·04
1875	74,328,000	3,037,000	4·08
1878	85,408,000	4,153,000	4·88

If, however, we eliminate from the total vote the amount expended for elementary education, the proportion left for science and art is considerably diminished :—

Year	Vote for Elementary Education	Vote for Science and Art	Proportion per Cent. for Science and Art
	£	£	£
1835	65,000	70,000	52
1845	150,000	150,000	50
1855	612,000	219,000	26
1865	1,019,000	341,000	25
1875	2,569,000	464,000	15
1878	3,624,000	529,000	12

The aid now given by the State to science takes the form of grants for salaries to professors in the Universities of Edinburgh, Glasgow, and St. Andrew's, where the professorships are insufficiently endowed; of payments to the University of London and other Universities for examiners in certain sciences; of sums devoted to the maintenance of royal observatories and museums of science and art; the support of schools of science and art; the cost of the Geological Survey; and the maintenance of the Royal Gardens at Kew and Botanical Garden in Edinburgh. In this manner the physical sciences are aided by 1,500*l.* for chemistry, 1,316*l.* for astronomy, and 100*l.* for physic. Geology, including the cost of the Geological Museum and Geological Survey, receives the sum of 33,373*l.* Meteorology, including the vote for the Meteorological Council, receives 14,987*l.*, and natural philosophy 841*l.*, making altogether the goodly sum of 50,801*l.* The natural sciences are well remembered. To natural history 200*l.* is awarded, to zoology 500*l.*, to botany 8,013*l.*, to agriculture 150*l.* The medical sciences receive for medicine 860*l.*, anatomy 680*l.*, surgery 750*l.*, materia medica 600*l.*, medical science

420*l.*, forensic medicine 250*l.*, Institute of Medicine 500*l.*, physiology 200*l.*, obstetric medicine 150*l.*; total, 4,410*l.* A grant is made of 475*l.* for engineering, and also 500*l.* for logic, 291*l.* for moral philosophy, 60*l.* for political economy, 450*l.* for law and jurisprudence, and 50*l.* for constitutional history. The amounts granted for the British Museum, 110,949*l.*, for the South Kensington Museum, for scientific research, and for schools of science cannot be classified with any precision. It is easy to see, however, that Government aid is principally given to physical and natural science, leaving a wide range of scientific exploration altogether unassisted.

Great have been the achievements of science in modern times, and England owes to its cultivators a profound debt of gratitude. Our manufactures and industry, our productive power and means of locomotion, all depend for their development on the advance of science, and our scientific societies have a high economic value. The Royal and Mathematical Societies are labouring to evolve the principles of those sciences which govern the phenomena of the material universe and the practical problems of the Law of Probabilities. The Statistical Society subjects the real worth of economic doctrine to the close test of numbers, the great corrective of experience, using the inductive rather than the deductive method in its researches for the guidance of the philosopher and statesman. The Royal Astronomical Society is expanding our knowledge of the meteorology and magnetism of the universe, as well as of the laws which govern the motion of the heavenly bodies, to the immense benefit of navigation. The Chemical Society is analysing matter, finding out new elements, and enriching the world with the knowledge of their capabilities. The Geological Society maps out for us the very strata of the earth. The Royal Geographical explores for us unknown regions, and makes us acquainted with the habits and wants of distant races. The Institute of Civil Engineers discusses those problems relating to railways, telegraphs, and steam navigation, which so especially distinguish this age of material progress. Much has been done in the pursuit of science, but much more remains to be accomplished; and England's hope to maintain her high position in productive industry must depend on the success which men of science may yet attain in fathoming the inexhaustible secrets of nature, on the increase in the number of patient yet ardent votaries of science, and still more on the diffusion of education and scientific knowledge among the great body of the people.

Local Societies.

Edinburgh Botanical Society.
Glasgow Natural Society.
Yorkshire Agricultural Society.
Yorkshire Philosophical Society.
Ulster Chemical Agricultural Society.
Wiltshire Natural History Society.
Norfolk and Norwich Archæological Society
Cambridge Antiquarian Society.
Worcester Diocesan Architectural Society.
Somersetshire Archæological and Natural History Society.
Tweeddale Physical and Antiquarian Society.
Lincoln Diocesan Architectural Society.
Suffolk Institute of Archæology and Natural History.
Liverpool Architectural and Archæological Society.
Lancashire Historic Society.
Glasgow Archæological Society.
Society of Antiquaries of Scotland.
Manchester Literary and Philosophical Society.
Edinburgh Philosophical Society.
Leamington Philosophical Society.
Leicester Literary and Philosophical Society.
Newcastle Natural History Society.
Liverpool Literary and Philosophical Society.
Falmouth Royal Cornwall Polytechnic Society.
Exeter Naturalists' Club.

Year	Royal Society	Statistical Society	Royal Astronomical Society	Chemical Society	Geological Society	Society of Antiquaries	Royal Geographical Society	Institute of Civil Engineers	Institute of Mechanical Engineers	Society of Actuaries	United Service Institution	Society of Arts	Royal Agricultural Society	Meteorological Society	Medical and Chirurgical Society
1830	734	—	—	—	617	849	—	—	—	—	—	—	—	—	—
1831	753	—	—	—	650	867	—	—	—	—	1,437	—	—	—	—
1832	748	—	—	—	649	838	—	—	—	—	2,699	—	—	—	—
1833	747	—	—	—	716	843	—	—	—	—	3,341	—	—	—	333
1834	770	—	—	—	745	832	—	200	—	—	3,748	—	—	—	—
1835	793	398	—	—	774	837	—	—	—	—	4,155	—	—	—	—
1836	793	390	324	—	810	828	—	252	—	—	4,069	—	—	—	329
1837	798	390	335	—	807	810	—	—	—	—	4,164	—	—	—	393
1838	789	392	346	—	831	769	—	—	—	—	4,175	—	—	—	389
1839	809	398	345	—	855	820	—	375	—	—	4,186	—	—	—	407
1840	812	416	350	—	862	828	—	424	—	—	4,257	—	—	—	427
1841	827	432	340	—	865	784	—	482	—	—	4,243	—	4,595	—	450
1842	825	429	349	—	868	780	—	525	—	—	4,127	—	5,834	—	492
1843	830	428	341	—	883	764	—	560	—	—	4,078	—	7,000	—	494
1844	824	422	337	—	875	736	671	532	—	—	3,968	—	6,927	—	575
1845	828	415	344	—	883	656	684	582	—	—	3,988	—	6,933	—	538
1846	841	411	365	—	894	642	695	600	—	—	4,031	—	6,971	—	550
1847	828	412	365	190	897	656	668	610	—	—	4,017	—	6,391	—	547
1848	812	406	344	224	899	584	627	626	189	—	3,947	672	6,335	—	538
1849	808	387	388	236	888	564	601	664	201	—	3,970	644	5,512	—	558
1850	798	380	412	249	825	546	607	681	203	244	3,997	990	5,261	—	578
1851	777	400	418	245	864	537	611	716	203	264	3,188	—	5,121	—	578
1852	767	396	441	241	867	524	610	745	204	244	3,078	1,118	4,981	—	589
1853	761	371	445	—	871	569	727	750	216	264	3,251	—	4,923	—	606
1854	745	367	450	247	884	619	804	773	228	245	3,171	1,418	5,177	—	611
1855	729	377	464	261	875	623	842	787	218	212	3,131	—	4,882	—	619
1856	720	391	447	256	866	623	907	797	259	177	3,204	1,755	4,979	—	627
1857	715	394	449	269	877	634	1,039	835	301	129	3,168	1,908	5,068	—	622
1858	706	359	436	277	872	635	1,206	857	341	144	3,246	—	5,146	—	628
1859	691	358	435	302	907	644	1,302	894	391	156	3,344	1,865	5,161	—	629
1860	673	374	435	365	922	647	1,354	930	428	147	3,518	—	5,165	—	631
1861	661	364	454	352	940	651	1,631	945	464	155	3,689	2,380	4,633	—	630
1862	660	368	480	444	969	652	1,750	1,000	497	167	3,797	2,826	4,823	—	642
1863	657	357	491	468	1,033	664	1,909	1,040	540	184	3,847	—	5,183	—	634
1864	655	365	484	497	1,092	648	1,987	1,095	572	198	3,902	3,012	5,496	—	626
1865	639	367	505	519	1,117	657	2,036	1,203	652	203	3,895	—	5,752	—	640
1866	626	364	511	539	1,149	651	2,097	1,339	728	220	3,891	3,164	5,622	331	630
1867	617	371	516	551	1,185	629	2,102	1,493	791	228	3,823	—	5,465	328	641
1868	600	387	528	518	1,204	622	2,150	1,694	825	221	3,812	3,134	5,461	330	665
1869	597	400	557	522	1,141	—	2,234	1,727	855	234	3,792	—	5,446	341	667
1870	597	403	554	551	1,163	—	2,263	1,876	862	255	3,831	3,122	5,438	340	665
1871	595	431	552	582	1,150	—	2,387	1,989	875	271	3,922	3,146	5,648	314	658
1872	587	454	573	624	1,154	—	2,448	2,123	912	296	4,116	3,181	5,766	309	652
1873	576	530	578	682	1,181	—	2,548	2,253	956	313	4,276	3,342	5,916	308	654
1874	571	588	597	733	1,209	—	2,719	2,411	992	324	4,330	3,545	5,846	327	654
1875	567	607	608	801	1,268	—	2,893	2,609	1,018	331	4,308	3,694	6,145	358	650
1876	561	611	620	881	1,298	—	2,982	2,844	1,041	335	4,320	3,777	6,486	398	651
1877	552	683	617	916	1,334	—	3,279	3,059	1,075	351	4,405	3,693	6,634	425	665
1878	549	746	631	937	1,336	600	3,332	3,315	1,140	362	4,484	3,686	6,797	480	666

2. *Report of the Anthropometric Committee.*—See Reports, p. 175.

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3. *Apprenticeship Schools in France.* *By* Professor Silvanus P. Thompson, *B.A., D.Sc., &c.*

The system of apprenticeship, as it has existed in England and on the Continent, is falling into decay from social causes, which render the education of the apprentice at the hands of his master impracticable. The question of apprenticeship is one of the knotty points of technical education, and involves the following problem:—How to give to artizan children (in the skilled industries) that technical training and scientific knowledge which their occupation demands, without detaining them so long at their schooling as to give them a distaste for manual labour.

Four distinct solutions of this problem are possible:—

1st. Send the children to work in the factory or workshop before their primary education is completed, making it obligatory all through their apprenticeship that they shall have every day a certain number of hours' schooling in a *school in the workshop*, or attached to it.

2nd. Keep the children at school as long as their education is unfinished, but set up a *workshop in the school*, where they shall pass a certain amount of time every day, so as to gain at least an aptitude for manual labour.

3rd. Organize *a school and a workshop side by side*, and co-ordinate the hours given to study with an equal number of hours devoted to systematic manual labour.

4th. Send the children half the day to the existing schools, and the other half to work *half-time* in the workshop or factory.

Illustrations of all these systems are to be found in Paris.

Of the first type there are no fewer than 237 in France, of which the schools of M. Lemaire and of MM. Chaix (in Paris) may be taken as excellent examples.

Of the second type of apprenticeship school is the École Communale d'Apprentis, in the Rue Tournefort, Paris. This is an ordinary elementary school, having workshops attached to it, and used for about three hours a day by the lads.

The third type, which is *par excellence* the apprenticeship school, is well illustrated by the École Municipale d'Apprentis of the Boulevard de La Villette, Paris, and by the Écoles d'Horologerie of Besançon and of Cluses. Statistical tables were given of the attendance at these schools, of the education given, of the capital and current expenditure per pupil, and of the results attained.

Fourth type.—Half-time schools are rare, and not very important in their results.

The author conceives that there is room for schools of all these different types to exist side by side in all large manufacturing centres, though schools of the first and third types are probably best suited to the conditions of British industry.

The author claims to have established, by facts drawn from the experience of the French schools,—

1st. That the systematic instruction of apprentices in the skilled industries is possible.

2nd. That it can be effected in several different ways.

3rd. That apprenticeship schools of one or other type afford a most satisfactory and economically sound way of attaining this result.

4th. That this *New Apprenticeship* solves the knotty problem of technical education which arose out of the decay of the Old Apprenticeship.

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4. *On Credit as an Asset of a State.* *By* Hyde Clarke, *V.P.S.S.*

The purpose of the author was to show, in illustration of his previous paper, 'On the Loans of Sovereign States,' that independently of all material natural resources and of capital, a State may possess credit, which will supply capital, and is to be reckoned as an asset. Taking a colony as an example, he pointed out that the natural resources, land, pasturage, harbours, water-power, rivers, forests, mines,

were, without the application of capital and labour, of simply nominal value. All the resources of such a State are applied to production, and transport is a condition without which production can merely supply local food, without producing exchangeable commodities. With the development of the means of transport by railways, new communities are no longer in a position to be self-sufficing in communications, and are dependent on the supply of external capital for rails, machinery, and works. These must be furnished by credit, and where credit cannot be obtained the country must remain undeveloped. This resource of credit has been unduly neglected in many States of the American Union, and in those of Central and South America. To ascertain the statistical value of this credit, he took the amount expended by the State, by municipalities, and by companies on public works, supplementing this by a further sum where the credit was unexhausted. Thus, Mr. Clarke estimated the minimum credit of Canada at 50,000,000*l.*, of New South Wales at 30,000,000*l.*, of Victoria at 30,000,000*l.*, of South Australia at 15,000,000*l.*, of Queensland at 20,000,000*l.*, of Tasmania at 5,000,000*l.*, of Natal at 4,000,000*l.* At zero, he estimated Bolivia, Costa Rica, Ecuador, Greece, Guatemala, Hayti, Honduras, Mexico, Persia, Peru, San Domingo, Venezuela. The cultivation and maintenance of credit he urged as an essential provision in the administration of a State, and as an immense resource. He contrasted England, the United States, Germany, and France, with Russia and China.

FRIDAY, AUGUST 22, 1879.

The following Papers were read:—

1. *On the Decay in the Export Trade of the United Kingdom.* *By* S. Bourne, *F.S.S.*

The question whether the diminution in the value of the exports of British and Irish produce and manufacture, which has undoubtedly taken place in recent years, is solely one of price and not in quantity, has given rise to considerable discussion. The Prime Minister, in his place in Parliament, has, on the authority of a report from the head of the Statistical Department of the Board of Trade—in which the trade of 1877 was compared with that of 1873—taken comfort from the thought that had the prices of 1873 been realised in the valuation of 1877, the two years would only have differed by a million of money instead of the apparent difference of forty-five millions, and most of the leading political economists have adopted the same view for other years. Yet there is reason to doubt whether the decay has not been to a great extent in volume as well as value—in quantity as well as price.

There is no difficulty in determining to which cause this is owing in the case of any single article of which we possess records, of both quantity and value; but where some have increased and others decreased it is only by analysing the returns, assigning to each item its relative proportion, and combining the results, that it can be ascertained to which or in what degree the preponderance of either cause is on the whole to be awarded. Tables are compiled for the seven principal articles of export, viz.: Cotton, jute, linen and woollen manufactures, coal, copper, and iron, contrasting the several periods—1877 with 1873, 1878 with 1872, and the first six months of 1879 with 1872—bringing out the following results.

(*In million pounds to the decimals.*)

		£	£	£
Value of specified articles ...	1877—	125·02	1878—120·62	1879—54·96
Value—being less than ...	1873— by	42·30	1872— 56·13	1872—28·50
Value of decrease in quantity		2·10	14·12	6·88
Value of decrease of prices...		40·20	42·01	21·62

These figures, however, fail to represent the true state of the case. In 1872–3 the price of coals was unduly inflated, and so of all articles in the manufacture of which coal is largely consumed. The valuations, therefore, for these earlier years require to be brought down to the average prices of previous and subsequent years. Again, a large portion of the value of the exports is to be found in the cost of the foreign materials of which they are composed, and the variations in the prices of these for the respective years needs to be estimated and allowed for. Dealing thus with coal, iron, and cotton, the above figures are thus reduced in every particular save that of loss in quantity, and will stand thus:—

	£	£	£
Net values for comparison ...	1873—113·88 1877— 98·02	1872—126·41 1878— 95·62	1872—60·77 1879—43·46
Difference due to quantity ...	2·10	14·12	6·88
Price ...	13·76	16·67	10·43
	15·86	30·79	17·31

These calculations dispose of the fallacy that in price alone has there been any serious decrease in the value of our exports, establish the fact that there has been a real decay in the quantity of our manufactures for sale abroad, and show that this is still proceeding at an accelerated pace.

TABLE I.

(*In millions to two decimals.*)

Goods Exported	Years	Total Value in Later Years	More or less than Earlier Year	Increase or Decrease in Value due to Quantity	Price
		£	£	£	£
Cotton Manfs. ...	1877 with 1873	64·22	— 7·54	+ 6·30	— 13·84
	1878 „ 1872	63·01	— 13·98	+ 5·14	— 19·12
(6 Mo.)	1879 „ 1872	28·27	— 8·34	+ 2·51	— 10·85
Jute „ ...	1877 „ 1873	3·28	— 0·43	+ 0·60	— 1·03
	1878 „ 1872	3·33	— 0·03	+ 1·35	— 1·38
(6 Mo.)	1879 „ 1872	1·64	+ 0·08	+ 0·85	— 0·77
Linens „ ...	1877 „ 1873	6·59	— 2·12	— 1·64	— 0·48
	1878 „ 1872	5·93	— 3·68	— 3·48	— 0·20
(6 Mo.)	1879 „ 1872	3·22	— 2·01	— 1·61	— 0·40
Woollen „ ...	1877 „ 1873	19·92	— 9·04	— 5·16	— 3·88
	1878 „ 1872	19·52	— 17·52	— 10·90	— 6·62
(6 Mo.)	1879 „ 1872	8·48	— 10·02	— 6·44	— 3·58
Coals	1877 „ 1873	7·84	— 5·34	+ 2·93	— 8·27
	1878 „ 1872	7·32	— 3·12	+ 1·79	— 4·91
(6 Mo.)	1879 „ 1872	3·34	— 0·63	+ 0·65	— 1·28
Copper	1877 „ 1873	3·06	— 0·22	+ 0·43	— 0·65
	1878 „ 1872	3·11	— 0·14	+ 0·98	— 1·12
(6 Mo.)	1879 „ 1872	1·50	— 0·09	+ 0·60	— 0·69
Iron	1877 „ 1873	20·11	— 17·61	— 5·56	— 12·05
	1878 „ 1872	18·40	— 17.66	— 9·00	— 8·66
(6 Mo.)	1879 „ 1872	8·51	— 7·49	— 3·44	— 4·05
Totals of specified Articles	1877 „ 1873	125·02	— 42·30	— 2·10	— 40·20
	1878 „ 1872	120·62	— 56·13	— 14·12	— 42·01
(6 Mo.)	1879 „ 1872	54·96	— 28·50	— 6·88	— 21·62

TABLE II.

(*In millions to two decimals.*)

	1873		1872		6 Mo. 1872	
Value of Specified Articles	£167·52		£176·75		£83·46	
Deduct Coal ...	£6·47	...	£4.06	...	£1·07	
„ Iron ...	13·17	...	9·28	...	4·12	
„ Cotton...	34·00	...	37·00	...	17·50	
		53·64		50·34		22·69
Net Value for Comparison		113·88		126·41		60·77

	1877		1878		6 Mo. 1879	
	£125·02	...	£120·62	...	£54·96	
Less Cotton ...	27·00	...	25·00	...	11·50	
		98·02		95·62		43·46
		Per ct.		Per ct.		Per ct.
Fall in Value ...		15·86 = 13·9		30·79 = 24·4		17·31 = 28·4
Due to Price ...		13·76 = 12·0		16·67 = 13·2		10·43 = 17·0
„ Quantity...		2·10 = 1·9		14·12 = 11·2		6·88 = 11·4

2. *Agricultural Statistics, Tenure, and Depression.* By WILLIAM BOTLY.

In previous papers I have shown the national importance of agricultural statistics, with illustrations from history, both sacred and profane, as being a safeguard against scarcity and famine.

I will now review the acreage of corn, green crops, flax, hops, &c., in the United Kingdom in 1878, with the number of cattle, sheep, pigs, and agricultural horses, with increase or decrease in the year 1878 as compared with the previous year 1877.

—	Acres	—	Acres
Corn Crops	11,030,175	Decrease	73,021
Green Crops	4,832,195	„	129,496
Flax	119,076	„	11,770
Hops	71,789	Increase	550
Bare Fallow and Uncropped Arable	650,238	„	16,743
Clover and Artificial Grasses under rotation	6,557,748	„	97,344
Permanent Pasture, exclusive of Heath and Mountain Land	24,065,394	„	162,080
*Orchard and Fruit-trees	165,415	Great Britain only, and of which there is no return since 1872.	
*Woods, Coppices, and Plantations	2,187,078		

* Orchards, Fruit-trees, Woods, and Plantations do not include Ireland, and are down to 1872 only.

Live Stock	No.	—	No.
Cattle	9,761,288	Increase	29,751
Sheep	32,571,018	„	350,951
Pigs	3,767,960	Decrease	216,487
Horses used in Agriculture	1,927,066	Increase	32,938

—	No.	—	No.
Oxen, Cows, Sheep, Lambs, and Swine imported in 1878 . .	1,201,500	Increase	103,206
Wool . . . . . lbs.	395,461,286	Decrease	10,487,875
Butter . . . . . cwts.	1,795,413	Increase	157,474
Cheese . . . . . „	1,965,949	„	314,861
Eggs . . great hundreds	6,529,036	„	271,144

Imported in 1878	Cwts.	Declared value	Increase in cwts.
Meat	1,307,954	£3,493,471	30,268
Wheat, Beans, Barley, Maize, Oats, Peas, and Flour .	88,238,700	58,372,624	Decrease in cwts. 35,740,804
Whilst the decrease in declared value is only			£4,836,884

The average price of wheat in the years 1863, 1864, and 1865 was 4*s.* 2*d.* below the average of 1878, whilst that of barley was 10*s.* per quarter lower in these years than in 1878, and for the said years 1863, 1864, and 1865 oats were 3*s.* 1*d.* per quarter below the year 1878. Meat averaged about three farthings per lb. more in 1865 than in 1868, and 1*d.* more in 1878 than in 1868. As no nation can allow its population to perish of hunger, or to suffer the terrible evils of and following upon scarcity and famine, it is an evident necessity to attend to these statistics.

From September 1, 1878, to the last week in July 1879, viz., *ten months*, the import of cereal produce was 102,747,256 cwts., of the declared value of 41,256,356*l.* Our exports were 2,286,869 cwts. in the ten months.

The tenant farmers of the United Kingdom are about 1,000,000, employing a capital of or about 400,000,000*l.* sterling. With security on judicious outlay it might be increased to five or six hundred millions, when they might farm at a profit instead of a loss, as we are continually told many are doing at present.

Peru was formerly the foremost as regards agricultural statistics, to its great advantage, and now our own magnificent Australian Colonies are pre-eminent for their elaborate and minute agricultural statistics. In all probability had a good system of that sort been established in India at a former period, the entire cost of the two famines—17,000,000*l.* sterling—might have been saved.

The importance of the subject of this paper is recognised by the mercantile and shipping interests as well as by that powerful engine and interest the press, and it was observed by the chairman at the meeting of the Royal Agricultural Society in December, 1877, that the earlier publication of our agricultural statistics was due to the papers read thereon before the British Association; and on May 22, 1879, at the meeting of the same Society, a prominent member advocated the obtaining, at any cost, by the Royal Agricultural Society of England, statistics of the agricultural produce of every clime and country in the known world, as essential to the interests of manufactures, commerce, shipping, and agriculture.

The fear of advance in rent, from these returns, is becoming less as knowledge advances.

Long and equitable leases, *i.e.*, security of tenure, will materially assist the onward improvement in agriculture, which, with compensation for all unexhausted improvements, will attract and bring more men of skill, capital, and enterprise into agriculture, and we shall then cease to hear the farmer calling for Parliamentary assistance, to which we must add that the game should be under the control of the tenant. With those equitable adjustments, the farmer need not fear foreign or colonial competition or prices. Moreover, as we have seen greater depression many times before, so when the other great industries revive agriculture will also improve.

3. *The 'German' Speech and Lip Reading System of Teaching the Deaf.* By David Buxton, *Ph.D.*

The number of those who are deprived of hearing, though relatively small, is larger than is commonly supposed, and quite large enough to form a very important item in that world of humanity with which science, and philanthropy taught and directed by science, have to deal. In the various populations of the world the deaf are probably not less in number than a million of souls; the distribution of this number is very unequal, no doubt, and varies not only in different countries but in different districts of the same country, as in our own for example, some counties in England showing twice and even three times as many deaf persons to the general population as are to be found in other counties not far distant. In the whole of Great Britain and Ireland at the census of 1871, the number of persons returned as 'deaf and dumb' was 19,237, being a proportion to the whole population of one in 1644, the local differences ranging from one in 1972 for England and Wales, to one in 975 for Ireland. In April 1881 the next enumeration of the people will take place. Many striking facts of recent occurrence have led thoughtful observers to the conclusion that our deaf population will then exhibit a considerable increase; that it will reach as high a figure as 30,000. The 'German' system of teaching the deaf is the only one which invokes science and applies science in its operations. That England does stand far in the rear of most other countries in respect of the teaching of her deaf children is as true as it is humiliating. She does not teach so many and she does not teach so well. The number of deaf children of the school age is always reckoned as sixteen per cent. of the whole deaf population. This on the census of 1871 would give us nearly 3200 as the number who should have been at school; the best calculation I was able to make showed that the actual number was under 2000. In July 1877 (according to the 'Organ,' a periodical devoted to the special subject), the institutions and schools for the 'deaf and dumb' in Germany numbered forty-nine, and contained 2932 pupils, under the instruction of 288 teachers, giving an average of 10·18 pupils to each teacher. The increase in the number of institutions within the previous two years had been nine, of pupils 682, of teachers 118. Probably, no other country can show equal progress during the same period. In 1872, the Swiss schools contained 344 deaf pupils, under the instruction of thirty-seven teachers: an average of nine to a teacher. What is the case in the institutions of Great Britain? A table compiled in 1877 gives 2340 pupils and a total of 171 instructors, including pupil teachers and deaf persons promoted out of the school to take the charge of classes. The number of these latter is thirty-three, and the number of female teachers, including fifteen nuns engaged at St. Mary's, Dublin, sixty-eight. This gives an average of fourteen to one teacher, the German average being 10·18, and the Swiss only nine per teacher. Thus, on the mere ground of numbers, we compare very unfavourably, but when we reflect upon the materials of which the teaching staff in England is so largely composed, it is no wonder that the subject is one which, in the minds of all who are interested in the welfare of the deaf, has for a long time created the deepest anxiety. Few of those who are engaged in teaching have entered upon the work with any special qualifications for it, none have been trained to it, and a very large proportion tire of it before they have acquired sufficient experience to make their teaching of any value. The superiority of the 'German' system nobody questions. Its bitterest opponents do not deny that; they only say, in effect, that the other is good enough for its purpose, that it is cheaper, and that in some cases where the time and capacity of the learner are limited, the 'German' method is inapplicable. But is this great country content to be put off with an inferior system in the matter of education to that which poorer countries are determined to have and willing to pay for? Germany is poor, especially Prussia proper. Switzerland is not rich, nor is Italy, nor Holland, in comparison with ourselves. Yet all these countries afford to support almost universally the 'German' system, which it has been alleged is so expensive as compared with the French. But is it a fact that the 'German' system requires

a larger staff of teachers than the other system? The best French teachers will not tell you so. Probably under any system eleven pupils are as many as any one teacher should be expected to attend to. But even if the better system is somewhat more expensive to work, surely, even in a commercial sense, it is worth the money.

SATURDAY, AUGUST 23, 1879.

This Section did not meet.

MONDAY, AUGUST 25, 1879.

The following Papers were read:—

1. *Elementary Natural Science in the Board Schools of London.* *By* Dr. J. H. GLADSTONE, *F.R.S., Member of the London School Board.*

In elementary schools a knowledge of the facts of nature is generally given in two very different ways. In the Infant department there usually linger some remnants of that instruction by object lessons which was considered a valuable part of education before the Revised Code of 1861. In the higher standards of the Boys' and Girls' departments certain sciences may be taught as 'specific subjects,' and receive encouragement by a Government grant.

The London School Board has all along desired that this knowledge of nature should not be confined to the least and the most advanced scholars, but should be extended throughout the whole course of a child's school life. It covers the walls of its schools with natural history pictures, and other diagrams, it gives a preference to teachers holding science certificates, it publishes full instructions to the teachers in regard to object lessons, and it provides a box of simple apparatus, and loan collections illustrative of various manufactures, animal physiology, and mechanics. On May 7 it unanimously passed a resolution that, 'In the opinion of this Board it would be expedient to include the elements of natural science amongst the recognised subjects of class examination, under Article 19, c. 1, of the Education Code,' and on June 27 a deputation of the Board presented a memorial to that effect to the Lord President of the Council.

At the present time, out of 1074 male and 1790 female teachers, 888 males and 442 females hold advanced science certificates, varying in number from 1 to 23, as will be seen in the following table:—

Teachers	Number of Advanced Science Certificates held											Total number of Teachers
	1	2	3	4	5	6	7	8	10	12	23	
Male . .	112	151	272	181	86	48	19	10	6	2	1	888
Female .	262	102	60	10	6	2	—	—	—	—	—	442

Object lessons may be assumed to be given in all the Infant departments, and are regularly reported on by the Inspectors of the Board. Advanced object lessons, generally on natural history, are taught in many of the Boys' and Girls' departments, and there is little doubt that they will soon become much more general and systematic.

Out of 248 boys', 218 girls', and 46 mixed schools, more than half include in their course of instruction scientific specific subjects, which are thus distributed:—

	Boys' Schools	Girls' Schools
Mechanics	1	—
Animal Physiology	99	13
Physical Geography	68	5
Botany	4	1
Domestic Economy	—	131

The cost of books and apparatus for the instruction in natural knowledge during the past twelvemonth was:—

Object teaching, diagrams, &c.	£587
Natural sciences	117
Domestic Economy (exclusive of cookery centres)	130
	£834

This amount forms a very small item in the £23,000, which was the expenditure of the year on books and teaching apparatus for the 205,010 children usually on the rolls, and is, in fact, rather less than one penny per child per annum.

There are other ways in which the Board works in the same direction: such as the placing of popular books on science in the school libraries, and the co-operation with the National Health Society in respect of the prizes in physiology which are offered to girls.

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2. *On Science Teaching in connection with Elementary Schools.* *By* J. F. Moss, *Clerk of the Sheffield School Board.*

The conditions under which grants in aid of elementary schools are given naturally suggest the consideration how far science teaching may be extended with the facilities already offered, and what improvements can be suggested in the direction of making science teaching more thorough and useful. The new code of regulations prescribes a certain course of training for every child attending a Government-aided school. The essential subjects are carefully arranged so that a child of twelve or thirteen should be fitted by such an education for any of the ordinary positions in life. There are also optional subjects, which include mechanics, animal physiology, physical geography, and botany. In the arrangements for the promotion of science teaching in connection with the Science and Art Departments there is a programme of twenty-four subjects in respect of which grants are given to teachers whose students attend certain classes and pass the prescribed examinations. It is undesirable to encourage the taking up of too many special subjects, any one of which would require an immense amount of time and hard work. Some teachers can produce most wonderful arrays of certificates, embracing subjects most comical in their variety, and involving studies widely different in their character. When we come to special science teaching, such as ought to be insisted upon, it will be obvious that the work should be well done, and can only be safely intrusted to those who devote themselves specially to a limited range of subjects, and who can be relieved of other responsibilities so as to admit of proper preparation and research. First of all we want really good teachers, and we should then attend to the necessity of economising their labours by framing such a system as will be calculated to secure the best results without waste of power. The teacher should be encouraged to concentrate his energies in whatever direction he is best fitted to follow, and should not be distracted by incongruous pursuits. At present the supply of really good science teachers is by no means sufficient, but as the field widens the demand will be met. Supposing we have the teachers, how can we best utilise and economise their work? The ordinary elementary school is scarcely the place best adapted as the sphere of operations; not that I would exclude elementary science teaching altogether from the lower schools, I would rather consider them as the place where should be discovered the adaptability of the pupil

for the profitable pursuit of advanced studies in one direction or another. Directly a pupil arrives at that point at which he may demonstrate his adaptability for special lines of training he should have the opportunity of availing himself of the best instruction he can get in that particular direction. This can be best carried out by providing centres at which the special training may be carried on under better conditions than is possible in separate schools. In every town of even moderate size there should be a special school to which might be drafted those pupils of either sex who demonstrate in their early career an adaptability for advanced training. For every special subject there should be special teachers of approved qualifications, training, and skill; one teacher might take a group of subjects. There should be scholarships or exhibitions enabling naturally gifted pupils to pursue their studies longer than would be possible without such helps, and the course of instruction should in each case be directed in view of a consideration of the position in life which the pupil is hereafter likely to fill. Branches of science more immediately bearing upon the industries of the district should be brought prominently forward, so as to provide for the training of young people who may hereafter be intelligent artisans, foremen, and managers. There need be no fear of educating young people beyond what is suitable for their station in life. The clever pupil should not be taken away from the elementary school at too early an age, so as to afford discouragement to his teacher there, and, on the other hand, he should be well grounded in all the essential subjects, so that he may pursue with the greatest benefit the special course. The expense of the scheme proposed would be less than might at first be imagined. Grants for special subjects, as already provided for in the new code, and the grants in aid of science and art teaching administered by the South Kensington authorities, should be available; they would produce more satisfactory results than those which are at present too commonly obtained. There should be also evening classes for the further advancement of students after they have entered upon their business career.

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3. *Some Account of the System of Instruction in Elementary Science introduced by the Liverpool School Board into their Schools.* *By* Edward M. Hance, *LL.B., Clerk to the Liverpool School Board.*

Almost as soon as the Liverpool School Board had any schools of their own to manage, they were painfully struck with what appeared to them the mechanical, monotonous, and utterly uninteresting character of the instruction then generally imparted in elementary schools. They felt that the incessant and almost entirely unrelieved grind at reading, writing, and arithmetic, in which the attainment of mechanical accuracy appeared to be the ultimate aim, did very little, if anything, to develop the intelligence of the children, and was calculated to defeat its own object by generating in a great majority of cases a distaste for intellectual attainments. They were impressed therefore with the necessity of providing a somewhat more varied curriculum, and especially with the importance of introducing some subject calculated to awaken the observing faculties of the children. In the choice of subjects they were by no means free, for though in theory they may perhaps be at liberty to introduce subjects not specified in the New Code of the Education Department, they are practically almost unable to do so, since teachers under a system of payment by results are naturally anxious to devote their main energies to subjects that will 'pay' in the Government examination. At this point the board obtained the valuable advice of Professor Huxley, Colonel Donnelly, and one or two other gentlemen of eminence in the world of science. The result was, at their suggestion the board selected 'Mechanics' for boys, and 'Domestic Economy' for girls, as the subjects most suitable for their purpose, the definition of these subjects given in the New Code being of such a nature as to allow of the instruction being considerably expanded, in the one case in the direction of elementary physics, and in the other in that of elementary chemistry, physics, and physiology. In reference to the system of instruction, it was decided to absolutely abandon the use of textbooks, and to rely entirely upon oral instruction, illustrated

by, or rather explaining, a series of experiments performed by the science instructor. It then became necessary to determine whether the children should receive instruction at their own schools or at certain fixed centres; the latter method would have greatly economised the time of the instructor and have diminished the number of lessons required, while it would have allowed of somewhat more delicate apparatus being used. In view, however, of the requirements of the Education Department, that the 'attendances' upon which a large share of the Government grant depends, shall each be of two hours' continuous instruction, and of the importance of having one or more of the teachers present at the demonstration, in order that they may subsequently go over with the children the subject of each lecture, it was decided to have the instruction given in each school separately. The system followed was this. The science instructor prepared for each week a lesson in mechanics for the boys of each of the two groups into which the schools of the Board are divided, and in domestic economy for the girls of one of these groups, that is, three lessons per week, of which each lesson necessitated a different set of apparatus. The lessons to one group would be given during the earlier, those of the other during the later days of the week. The requisite apparatus was transported from school to school in a small hand-cart by a boy specially employed for the purpose. By this means the instructor was enabled to give four lessons each day, or twenty in the course of the week. In each school the children in the three upper Standards (IV., V., and VI.) were during the first year grouped together into one class for the purpose of this instruction, but after the following examination by the Government inspector, when the children were all moved a standard higher, and those who had previously formed Standard III. entered on Standard IV., a second class became necessary. This increased the number of lessons required in each week, and it became necessary to appoint an assistant to the original science instructor, and now after the expiration of a second year, and the formation of a third class in each school, a second assistant has been required; but, in the instruction of the later stages—when the children have been already well grounded in the subject—a larger share is left to the ordinary teachers of the school, so that the actual demonstrations given by the science instructor or his assistants in each school are as follows. Boys, Stage I., one lesson per week; boys, Stage II., one per fortnight; boys, Stage III., one per month. Girls, Stage I., one lesson per fortnight; Stage II., one per fortnight; Stage III., one per month. Although a large proportion of the demonstrations are now given by the assistants, each lesson is still prepared by the science instructor, and is actually delivered by him in one school in the presence of the assistant, who is afterwards to give that lesson in other schools. The number of children now under instruction is about 2700, and will shortly be 3,000. The cost to the board has been about 100*l.* for the stock of apparatus, and about 470*l.* a year for salaries to the instructor and his assistants. This amount is diminished by one half the grant earned from Government, the other half being for each school paid in equal proportions to the science instructor and the head teacher. The experiment has so far been very successful, the demonstrations are extremely popular with the children, and have made a perceptible increase in their intelligence, especially among the elder children, and even more markedly among the girls than the boys.

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4. *Reformatory Punishment.* *By* F. T. Mott, *F.R.G.S.*

The reformation of the criminal is the only basis of social punishment which is consistent with the highest morality. Upon this principle the following system of punishment is suggested, viz.:—1. That the criminal, when convicted, should be removed from those influences under which the crime has been committed, and treated as a weak and selfish child. 2. That he should be detained for no definite period, but until he has given evidence that he is not likely to commit crime again. 3. That prison discipline should consist in teaching every one to labour for the benefit of the others, the principal test of reformation being the willingness to sacrifice ease and comfort continuously for the good of others. 4. That Courts

should be established, with the best guarantees obtainable for impartiality and practical wisdom, to determine when each criminal is fit for freedom.

The first result of this system would be to clear the country of habitual criminals, and to fill the jails; but in a few years crime would be much diminished, and the moral tone of the people greatly elevated.

5. *On the Feasibility and Importance of Extending to Scotland the proposed Criminal Code for England and Ireland. By* W. Neilson Hancock, *LL.D., M.R.I.A.*

The criminal code first proposed for England only, after inquiry, was proposed to be extended to Ireland also. A delay has occurred in passing it, which afforded an opportunity of including Scotland also. The system of public prosecution so long prevailing in Scotland, and partially adopted in Ireland, had been partially adopted in England. The complete system in Scotland led to some great economies and simplification of procedure, in dispensing with the double preliminary inquiry before coroners and magistrates and the double attendance of witnesses before grand juries and petit juries, the Scotch dispensing altogether with inquests and with grand juries, except in cases of treason. If grand juries were preserved for the two classes of cases of private prosecution and treason and offences against public authority, the double attendance of witnesses might be obviated in the vast majority of cases, and grand juries would not be necessary in Scotland to a greater extent than at present. The English Metropolitan police report shows numbers of cases abandoned from cost and trouble of prosecution. The system of inquests might also be limited to a few cases to be conducted more on the plan of Board of Trade inquiries as to ships, and railway inquiries as to accidents, and a few other special cases, so the Scotch would not have to adopt inquests. The Statistical European Congress held at St. Petersburg in 1870, recommended uniform criminal tables for all Europe. A criminal code is the first step towards uniform statistics for England, Scotland, and Ireland. The value of statistical comparison is shown by some results of the first complete comparison of Scotch, English, and Irish crime. In the same population the English figure for crimes against property with violence was 1,014, the Scotch 3,175, and the Irish 458. The Scotch figure for assaults and breaches of the peace 98,145, the English 22,000, and the Irish 38,351. The first excess was accounted for by the peculiarity of the Scotch Poor Law which prohibited guardians from relieving the able-bodied, however great their distress might be. The second by the weakness of the Scotch in police, only 5,034, as compared with 12,546 for Ireland, and 6,670 for England in the same population. The paper also suggested the importance of reducing the law as to offences disposed of summarily to a code.

TUESDAY, AUGUST 26, 1879.

The President delivered the following Address:—

I cannot commence my address to the present meeting of this Section without referring to the very brilliant essay delivered last year at Dublin by my predecessor, Dr. Ingram, and which has justly attained an European fame and circulation. It was at once a vindication of the claim of Sociology to a high place in the proceedings of this Association, and a protest against the somewhat narrow limits and methods which political economists have for some time past imposed on themselves. With most of his arguments and statements I cordially concur. So far from

agreeing that this is a time when we should abandon sociological inquiry as beyond the limits of true science, I venture to think there never was a time when it was more desirable that these subjects should be treated in a scientific manner.

I do not purpose, however, on the present occasion to follow Dr. Ingram further in his philosophical disquisition on the proper limits of economic inquiry, but I shall endeavour to deal with one of the many questions which are unquestionably open to us.

There can scarcely be a more interesting economic question at the present time than the state of agriculture and the causes of its present depression. How deeply important is it that we should be able to trace the causes of that depression, to analyse how far they are of a climatic and temporary character, and how far they are due to the competition of foreign produce; to what extent also the low prices are due to the alteration in value of gold; and, having ascertained this, to discuss how far we may expect these causes or any of them to continue or to diminish in their effect, and to estimate their ultimate effect upon rents, on wages, and on the profits of farmers, and indirectly upon other interests of the community.

Pending the investigations of the Royal Commission recently appointed to consider the subject, it may seem almost an act of temerity to venture upon it; but the Report of the Commission will probably not be forthcoming for two years; in the meantime events will not wait for it, and it is desirable that every light should be thrown upon the subject by independent criticism and observation. I feel also that I owe no apology for so doing, for although the community in which we meet is essentially a manufacturing one, yet it will be admitted that the depression of a great interest like that of agriculture has a serious import and effect upon every other interest in the country, and is probably at this moment one of the causes of the stagnation which is so much complained of in the manufacturing world.

It must be admitted most freely that the agricultural interest, or at least a large part of it, has suffered severely during the last few years from a combination of bad harvests and low prices. These phenomena are especially to be noted since the year 1873; of the six years including and following that year, four have been years of exceptionally bad harvests, giving results of from 20 to 25 per cent. below the average; and for the whole period the average production of cereals has been 13 per cent. below the average. In the memory of living men there has been no such concurrence of bad seasons.

Bad harvests, however, in previous years were generally followed by higher prices, which recouped the producers to a great extent for the deficient quantity; but bad harvests during the last six years have not only not been followed by higher prices, but in the case of wheat at least, prices have fallen still lower, and the consequence has been most serious to those who rely mainly on this cereal. But when, in addition to the low price of wheat, we take into account the reduced acreage of corn cultivation, the reduced number of cattle owned in the country, notwithstanding the greatly increased price of meat, and the rise of wages of agricultural labourers which occurred in 1872, we can easily realise the great losses of those farmers who rely mainly upon corn for their returns, and who cultivate the heavy and inferior lands of this country.

The produce of wheat is so important a part of the agricultural industry of so large a proportion of the country, that it may be taken as to a great extent an index of the position of agriculture; its abundance and price are also of not less interest to the bulk of the population of this country, who rely upon it mainly for their food. It is worth while, therefore, to pay special attention to this product. The position of the producer with respect to it may best be estimated by multiplying the known average produce per acre in each year by the average price obtained for it in the twelve months succeeding the harvest.

I have before me a table constructed on this basis, showing the average product in money per acre of wheat for each year since 1849. It shows that for the first four of these years following shortly after the repeal of the Corn Laws the production of wheat must have been anything but profitable to farmers; the harvests were somewhat above the average, but the prices were very low, averaging only 41*s.* per quarter, and the result in money to the farmer for an average acre of produce

was only 7*l.* 9*s.*; after that year prices again rose, and for the next twenty years the average product per acre in money was 9*l.* 13*s.*, or 2*l.* 4*s.* per acre above that of the four years succeeding 1848. During these twenty years it is to be observed that the price of wheat as a general rule varied inversely as the quantity produced, in other words, a very good harvest was succeeded by lower prices than the average, a bad harvest was followed by higher prices, and the farmer was compensated in a great degree by a higher price for the deficiency of the harvest; thus in 1863 the best harvest of the period, the production was 41 per cent. in excess of the average, and the price fell to 40*s.* 11*d.* per quarter, the result to the farmer being 10*l.* 0*s.* 6*d.* per acre; and in 1867 the harvest was the worst of the period, 26 per cent. below the average, but the price rose to 68*s.* 4*d.* per quarter, giving a result to the farmer of 8*l.* 17*s.* per acre.

In 1873 we observe a marked change in this relation between quantity and price, and it is obvious that some causes must have operated from that time to depress prices to a very marked degree. Unfortunately for the producers, the six years which followed 1873 have been years of very serious deficiency of production; as already shown the harvests have been 13 per cent. below the average. In lieu, however, of rising in proportion to this deficiency, the price of wheat has fallen somewhat lower than on the average of previous years. It has been 49*s.* 7*d.* per quarter, as compared with 55*s.* 5*d.*, the average of the previous six years of good harvests; the result, therefore, in product per acre has been an average for the six years of only 7*l.* 9*s.*, or exactly the average of the four years 1849–52, while the average of the last four years has been even lower, namely, 7*l.* 4*s.* 5*d.* per acre, or 2*l.* 8*s.* 6*d.* per acre below the average of the twenty years from 1853 to 1872. It is obvious from these figures that the reduced product per acre is due, not merely to the deficient quantity, but also to a fall of prices; and so far from the prices having risen in inverse proportion to the bad harvests, there has been a distinct tendency to fall in spite of the bad harvests.

From these figures it is easy to estimate how great has been the deficiency to the producers of wheat upon their average crops of the last six years. The present extent of wheat production in the United Kingdom is about 3,300,000 acres, and compared with the average of the previous twenty-four years, including the bad years succeeding 1849, the last six show a reduction of gross product of about 2*l.* per acre, equal to an annual reduced gross return of 6,600,000*l.* For the six years, then, the reduced return to the producers of this cereal has been 39,600,000*l.* It is quite clear, then, that the position of those farmers who rely upon wheat for their main profit, and who have suffered most from the wet seasons of the last few years, has been very serious, and the prospect of another bad harvest must be most discouraging to them.

Before, however, we examine the causes of this, and speculate as to the future, let us look at the question from the point of view of the consumers. To the public who are consumers the failure of the harvest is a matter of as much regret as to the producers. It is the interest of all that the product should be plentiful. It cannot, however, be said to be equally the interest of all that the price of wheat should be high, or even that it should rise in proportion to the deficiency of harvest. If the increased price were paid wholly to the producers of this country, the money would at least remain here and be circulated again among the community; but as the greater part of the wheat consumed now comes from abroad, a rise in value not only raises the price to the home producer but also to the foreign producer, and the increased price paid to the consumer is so much loss to the country as a whole. For many years past the proportion of importations to the home production of wheat has been increasing. Thirty years ago we imported little more than one-fourth of our total consumption, during the last six years we have imported considerably more than the half our total wants. Comparing the last six years with the previous six years, it will be observed that the proportions of home growth and foreign imports have been reversed; in the first period we produced 12,000,000 quarters and imported 10,000,000; in the second period we produced 10,000,000 and imported 13,000,000 quarters.

The following table will show at a glance how rapid has been the growth of

imports, and how more and more this country is becoming dependent for its supplies on other countries:—

Average Population, Production of Wheat, and Importation, for periods of 6 Years.

Periods of 6 Years	1 Average Population of United Kingdom	2 Average acreage under cultivation of wheat in each year	3 Average production of wheat in each year	4 Average importation of wheat in years succeeding harvest	5 Total average consumption of wheat in each year
			qrs.	qrs.	qrs.
1849–54	27,666,000	4,267,000	14,763,000	4,207,000	18,970,000
1855–60	28,688,000	3,836,000	13,812,000	5,873,000	19,685,000
1861–66	29,760,000	3,625,000	13,052,000	7,760,000	20,812,000
1867–72	31,370,000	3,562,000	12,343,000	9,667,000	22,010,000
1873–78	33,102,000	3,313,000	10,089,000	13,050,000	23,139,000

[The table is constructed on the basis of Mr. Caird's table, showing the production of wheat per acre for each year since 1849; on the trade returns from which column 4 is arrived at; and from the agricultural returns, which give the acreage under wheat cultivation for the last few years; the acreage for the first three periods is estimated, after taking into account the importations, the requirements for consumption, and the known produce per acre.]

The price of wheat has averaged during the last six years 6*s.* per quarter less than the previous six years. The consumer, therefore, has been saved that much on each year on the total average consumption of 23,000,000 quarters, or a sum of 6,900,000*l.* a year, a saving nearly sufficient to pay for the excess importations, as compared with the previous six years. But this is not the whole of the case; if the price of wheat had risen during the last six years in inverse proportion to the deficiency of product, as it has already been pointed out was generally the case in the previous 20 years, it is easy to show that the average price during the six years would have been 62*s.* 6*d.* per quarter, in lieu of 49*s.* 6*d.*, a difference of 13*s.* per quarter. This increase would have been paid by the consumer upon the average consumption during the six years of 23,139,000 quarters, making an increased charge to the community of about 15,000,000*l.* in each year; and of this 6,550,000*l.* would have gone to the home producer in each year, and 8,450,000*l.* to the foreign producer. For the six years, therefore, the home producer would have gained 39,000,000*l.*, and nearly 51,000,000*l.* would have been paid away to the foreign producer, in excess of what was actually paid.

It is clear, therefore, that the country, as a whole, has very greatly benefited by the low price of wheat; and it is not too much to say that had this additional sum been paid away for wheat during the last few years of depression, in addition to proportional increased payments for other food supplies, the commercial depression would have been greatly aggravated.

The low price of food has unquestionably been the chief cause that the working classes have passed through the period of commercial depression with so little general suffering. It has also been the cause that one of the three great classes which make up the agricultural community, namely, the labourers, have been better off during the last six years than they have been during any period in the last century. Not only did they succeed, in 1872, in asserting a rise in wages, but their money wages have, owing to the low price of wheat, gone much further. A rise of 13*s.* per quarter of wheat would have almost neutralised the rise of money wages.

A consideration of these facts will, I think, show how immensely the country gains by the low price of wheat, and that such gain is altogether out of proportion to any loss which may be incurred by the producers in this country, of that proportion of the consumption which they are able to produce. It will also show how

impossible must be the attempt to revert to any expedient for artificially raising the price of wheat in the interest of the home producers. Any arguments there may have been 30 years ago in favour of such a course, are multiplied tenfold at the present time, when the proportion of imports to home produce is so greatly altered.

Let me now revert again to the table showing the gross product in money per acre of wheat. I have already pointed out that in the year 1873 there evidently came into operation causes which exercised a very powerful influence on the price of wheat, and which prevented its rise at a time when deficient harvests would have led us to expect a very considerable rise. I do not think it is difficult to trace and determine one and the main of these causes. It appears to me to be very intimately connected with that which is the main cause of the commercial depression of the last few years. We know that between the years 1869–1872 there was an extraordinary inflation of trade in America, due mainly to the enormous extension of railways in the Western States; this was in a great measure stimulated by reckless and unwise concessions of Congress, which gave away millions of acres of land to the companies who obtained concessions for their lines, and by reckless and unwise lending by capitalists and investors in this country and Germany. In four years not less than 17,000 miles of new railways were constructed. The installation of these new lines, and the consequent speculation, led to an enormous and unnatural development of the iron and coal industries in America, and to immense importations of iron rails from England; it also stimulated prices generally, and was a main cause of the inflation of that period.

The immediate result of this vast extension of the railway system in the Western States was to bring to market a great amount of corn already being grown in those districts, and which had hitherto been beyond the range of the English markets, and the effect of this doubtless began to be felt on the price of wheat in England about the year 1873.

Its next effect was to produce a reaction and collapse without parallel to any which we have experienced in the last 30 years. The collapse was mainly felt in the American States. In 1873 no less than 7,000 miles of railway became bankrupt and were sold up by their creditors. The iron manufactures which had been called into existence were involved in the collapse; nearly one half of those in the States stopped work. The importation of iron from England fell to zero. The loss of capital engaged in these new railways and ironworks told in a hundred ways upon the commercial prosperity of the States, and indirectly, though by no means to the same extent, upon our own. Thousands of labourers were thrown out of work in the manufacturing districts of America. Their imports fell off by 40,000,000*l.* a year, or 32 per cent. There is no better illustration of the distress caused in America than the almost total cessation of emigration to it from this country. The intending emigrants soon learned that they had nothing to gain by transferring themselves across the Atlantic. There was greater difficulty in finding work in New York, Philadelphia, and even Chicago, than at Liverpool or in Ireland. In each of the years 1872 and 1873 the emigrants had numbered 230,000, in 1876 and 1877 there was an excess of returning emigrants.

What followed must have affected, even more powerfully, the prices of agricultural produce in this country. The great surplus of unemployed labour has during the last five years been transferred from the manufacturing districts and great towns in the Atlantic States to the new districts opened out by the railway extension of the previous years. The cultivation, therefore, of corn in these newly opened-out fields has increased at a ratio never before experienced. The new railways, constructed before there was population or trade to supply them, stimulated this new settlement by lowering their traffic rates to a minimum; the commercial depression operated upon the steam-carrying trade across the Atlantic in the same manner, and greatly lowered freights; coincident with this movement there has been a succession of abundant harvests in America, while this country was suffering from such deficient harvests.

So great a movement in the direction of increased cultivation of the surface of the earth has probably never been yet experienced in so short a period, nor has

there ever been so rapid and great a reduction of the cost of transit, both by land and sea.

The following table taken from official returns shows the growth of production of wheat alone in the United States:—

	1849 Bushels	1859 Bushels	1869 Bushels	1877 Bushels	1878 Bushels
Atlantic States	51,657,000	53,294,000	57,476,000	64,344,000	65,000,000
Central States	43,522,000	94,458,000	140,877,000	147,890,000	150,000,000
Trans-Mississippi States	5,306	25,352,000	89,392,000	152,860,000	215,000,000
Total	106,485,000	173,100,000	287,745,000	365,094,000	420,000,000

The aggregate production of wheat has increased from 100 millions of bushels in 1849 to 365 millions in 1877, and 420 millions in 1878, and the production per head of the population, notwithstanding that the population has nearly doubled in the interval, has increased from 4·33 to 7·87. Not less interesting is the relative increase in different sections of the country. In 1849 the production beyond the Mississippi was insignificant. The production of the Atlantic and the Central States was not far from equal, each about 50 million bushels. The production of the Atlantic States has increased but very little in the 30 succeeding years; it is now only 64 million bushels. The production of the Central States doubled in the decade ending 1859, and increased again by 50 per cent. in the decade ending 1869, while the trans-Mississippi production, which amounted to 25 millions in 1859, rose to 90 millions in 1869, and to 215 millions in 1878; the whole increase, therefore, in the last seven years has been in the States beyond the Mississippi.

From 1870 to 1878 the area under cultivation of wheat in the States increased from 19 millions of acres to 30 millions, and of maize from 38 millions to 50 millions; and the exports of wheat alone increased in ten years from 50 millions of bushels to 90 millions, of which this country has taken more than half. Of the total importations of wheat to this country the production imported from the United States has increased from 26 per cent. for the six years ending 1872, to 44 per cent. for the last six years, or, including Canada, about 50 per cent. For the 12 years ending 1866, the proportion was 35 per cent. The figures show that the relative capacity of America for supplying this country with wheat had greatly fallen off during the six years preceding 1873, but since then has enormously increased.

The excess production of the American States and Canada beyond the wants of their own population is at the present time sufficient, in average harvests on both sides of the Atlantic, to supply the whole excess wants of this country; and the actual acreage under wheat cultivation is nearly ten times the extent under similar cultivation in this country.

In view of these facts, who can be surprised that the price of wheat in this country should have been so profoundly affected? The result of the movement in the States during the last eight years, of the vast extension of cultivation, combined with the cheapening of the cost of transit, has been almost to annihilate the distance between the two countries, and to subordinate the production in this country to the vastly greater production on the other side of the Atlantic. It has rendered us comparatively indifferent, so far as our interests as consumers are concerned, whether we have good or bad harvests in this country, and a complete command over the markets here has been given to the vastly greater production of the far West.

Is it then to follow that the cultivation of wheat in this country is, in the future, to become impossible, because unprofitable? Is the price to be so permanently reduced as to prevent its cultivation upon any but the very best soils? We should, I think, be wrong in forming any such conclusion. It must be recollected that the last six years have been years of most exceptionally low production in this country; the competition of America has been much more felt in the bad

seasons than in the good seasons; it has had the effect of preventing the rise of price in bad seasons. We can scarcely as yet estimate its effect upon the price in average seasons or when harvests are above the average in this country. The bad harvests here have been balanced by exceptionally good harvests in the States; we have yet to learn what may be the result upon prices here of indifferent harvests in America. A diminished production of one bushel to the acre in this country results in a loss of less than half a million of quarters; a reduction to the same amount in the United States will produce an aggregate loss of three and a half million quarters, or one-third of her exporting power. A general bad harvest, therefore, may even now materially interfere with her exports. In 1859, and again in 1865 and 1866, the exports from America were reduced to very small amounts by bad harvests, after having been exceptionally large, and there may be similar variations in the future. It is probable also that the effect of the recent bad seasons and low prices will be to reduce still further the acreage of wheat cultivation in this country. In future, therefore, we must look for an ever-increasing requirement from abroad for our wheat consumption. An average harvest in this country will produce not more than eleven million quarters, leaving twelve millions for imports. A harvest 20 per cent. above the average will still necessitate the importation of ten millions. It is quite possible, and indeed probable, that a bad harvest in the States, coincident with a good harvest here, may raise the price of wheat so as to give a large profit to the farmer. There are many questions also affecting the future production in America and the future balance remaining for exportation which have to be considered. The increase of population there is rapid; new districts become quickly peopled; States which a few years ago were large exporters are now producing no more than sufficent for their own consumption; others are become importers, and every year the centre line of wheat production is being carried farther to the westward. A general revival of trade will probably increase the traffic rates of the Western railways and the Atlantic freights. These and many other causes may in future tend to raise the average price of wheat and other agricultural produce in the States.

If I were to venture a prediction on so difficult and obscure a question, I would incline to the opinion that wheat has during the past year reached its lowest point; that we have felt the maximum of the effect of the recent great extension of corn production in the Far West; that with the revival of trade, the increase of population both here and in the States, and the tendency to reduced cultivation of wheat in this country, there will be a rise in the price of wheat; and that, coupled with better harvests in this country, or, at least, a return to average harvests, we may find the product to the farmer in money such that the difference as compared with the past is capable of adjustment by a comparatively slight reduction of rent and wages.

The business of farmers, especially in this country, where it is separated from the ownership of land, and is connected with the land only by contracts of short date, is one which cannot be carried on without such a rate of profit as will induce capital to embark in it. It is certain, therefore, that such an adjustment of profits, rents, and wages must be made as to enable the business to be carried on, and it is probable that this adjustment will be made before the Royal Commission recently appointed can conclude its labours.

It may be worth while to point out that the competition of the Far West has told upon other lands much nearer to it than our own country. The farming interest of the New England States, and even of some of the other Atlantic States, has been much affected by it during the last few years. The value of land in these States, remote from the larger towns, has been much reduced, and large numbers of farmers from New England have been induced to leave their homes and settle in the new opened-out district in the West. Their place has been taken in part by Irishmen and in part by Frenchmen from Canada, who are content to farm in a more humble manner, and who can get a living by laborious and minute attention which their predecessors disdained to give to the land. At the same time a great change has come over the manufacturing industry of New England. It is not many years ago that its factories were mainly supplied by the sons and daughters

of the New England farmers of the true Anglo-Saxon descent. This class has now all but disappeared; the factory workers are now Irishmen or Frenchmen, and form a true manufacturing population. The true New Englander is rarely found there, except in a position of trust as overlooker or manager. The change which has taken place, and the depreciation in the value of land, has not affected the total value of property in New England. The low price of food has been a great benefit to the manufacturing industry, and the aggregate wealth of these States never was greater than at the present time.

If the competition of the great corn-fields of the Far West has thus told upon States so near at hand, it is to be expected that some of its effects would be felt in this country. Although the position of the farming interest for the twenty years preceding 1873 was satisfactory and fairly prosperous, yet it was certainly not progressive. The cultivation of wheat has gradually diminished, and the breeding and feeding of cattle has been substituted for it; the dependence of this country upon foreign produce for its food has every year become greater; the number of persons employed in agriculture has remained stationary, and their proportion to the rest of the population has been continually diminished. The whole increase of population during the last forty years has been absorbed in other pursuits than agriculture. In 1831, 28 per cent. of the population of England and Wales was occupied in the business of agriculture; the proportion is now less than one-tenth; and great as still is the importance of the agricultural interest as compared with any other, its relative importance to the whole manufacturing and commercial interests of this country is greatly changed. That, notwithstanding this, the wealth of the country has increased by enormous leaps and bounds in the interval is indisputable, and especially was this the case in the few years preceding 1873. That we have been able to provide for a population increasing by about three millions in every ten years, without any increase of territory, and with a somewhat reduced agricultural industry, that we have been able to turn the tide of pauperism, and to reduce it considerably as compared with the past, is a most striking fact, and strong testimony to the soundness of our general system. It may be that the enormous agricultural development in America will drive us further on the same road; but that it will permanently injure the economic condition of this country as a whole is not to be believed.

If, then, I am right in my explanation of the agricultural depression, it may be connected not remotely with the depression which has weighed so heavily upon commerce and manufactures also during the last five years. Both are probably due in the main to causes operating over a great area and over a long period, and are indications of the flow of the great tide of population and cultivation advancing over the great plains of America. The collapse of credit in 1873, and the consequent discredit and depression, has been much more felt on the other side of the Atlantic than on this. The imports to the States fell off enormously; the investment there of foreign capital wholly ceased. In this country we have felt severely the temporary loss of our largest customer for our exports;[1] but our other customers in every part of the world have made up for the bulk of our exports, though not for their value.

I am confident, however, it will be found, on making a comparison between this country and others, that we have passed through the period of depression with infinitely less suffering to the bulk of the people, and with less real loss of capital, than in any other part of the world—excepting perhaps France, which has been saved by the extraordinary thrift of her working population; and that free imports and consequent low prices have saved the labouring classes from what would otherwise have been a period of far greater distress to them. Already there are symptoms of revival in that quarter from whence the principal cause of the depression issued. All accounts from America testify to the improved condition of trade, to the fact that the immense extension of agriculture is producing its natural effect in reviving a demand for manufacturing products, which her own workshops will soon be unable to supply. With reviving trade and renewed confidence in America, the investment

[1] Our exports to the United States fell from an average of 36 millions for the three years ending 1873, to 16 millions for the last three years.

of capital will again flow towards it, and we may again confidently expect a renewal of our export trade. It is impossible the people of the United States can long continue to supply the world with food and take nothing in return for it. On the other hand, all past experience shows that in spite of high duties and protection rates, a great import trade may exist, and may find the means of overcoming all the impediments of hostile tariffs. Within the last few weeks we have heard of an order for 20,000 tons of rails, to be manufactured in this town, and to be delivered at New York, where the duty payable will be more than the cost price at Sheffield. The trade returns of the last few months likewise show that in every item enumerated there is a great increase of exports to America. As the United States, therefore, have been the main cause of the past depression, so they may in the future be the main cause of a reaction; and the reaction which will tell first in trade and manufactures will certainly later reach the agricultural interest.

It appears to me, then, that it would be a most useless waste of time and energy to expend efforts in trying to reverse the commercial system established by Sir Robert Peel in 1846, or in making inquiries with a view to a return to exploded fallacies and obsolete systems; but it is a time, when attention having been so much directed to the condition of agriculture, we may with great advantage inquire whether the conditions under which it is carried on in this country are such as to attract and encourage to the utmost the application of capital and labour to the land; whether a system of tenure which seems calculated to forbid the combination of ownership and occupation, to prevent security for improvements effected by the occupier, and to accumulate land in the hands of persons who are frequently unable to afford capital for its improvement, is the best suited for the development of agricultural industry. Although changes in such a system may not be fraught with immediate remedies for present depression, and may not affect the price of produce, yet they may tend ultimately to place the cultivators in a better position to meet the varying conditions of the future; which in agriculture, as in other trades, must be expected to present alternate periods of prosperity and loss.

APPENDIX.

Year of harvest	Production of wheat per acre as compared with standard of 100 per acre	Production per acre in qrs. of wheat	Average price of wheat during 12 months succeeding harvest		Average crop produce per acre for wheat represented in money, excluding value of straw		
			s.	*d.*	£	*s.*	*d.*
1849	123	4·3	40	4	8	13	5
1850	102	3·6	39	10	7	3	5
1851	110	3·9	39	7	7	14	4
1852	79	2·8	44	7	6	4	10
1853	71	2·5	72	11	9	2	3
1854	127	4·4	70	0	15	8	0
Avrge. for 6 yrs.	102	3·6	51	0	9	1	0
1855	96	3·4	73	11	12	11	4
1856	96	3·4	60	1	10	4	3
1857	124	4·3	47	8	10	5	0
1858	116	4·1	43	9	8	14	4
1859	92	3·2	48	3	7	14	5
1860	78	2·7	55	3	7	9	2
Avrge. for 6 yrs.	100	3·5	54	10	9	7	0
1861	92	3·2	58	1	9	5	10
1862	108	3·8	47	7	9	0	10
1863	141	4·9	40	11	10	0	6
1864	127	4·4	40	0	8	14	0
1865	110	3·9	46	6	9	1	4
1866	90	3·2	60	4	8	13	1
Avrge. for 6 yrs.	111	3·9	49	0	9	2	0

APPENDIX—*continued.*

Year of harvest	Production of wheat per acre as compared with standard of 100 per acre	Production per acre in qrs. of wheat	Average price of wheat during 12 months succeeding harvest	Average crop produce per acre for wheat represented in money, excluding value of straw
1867	74	2·6	68 4	8 17 8
1868	126	4·3	49 11	10 14 8
1869	102	3·6	46 2	8 6 2
1870	112	3·9	54 2	10 11 3
1871	90	3·2	56 7	9 1 1
1872	92	3·2	57 3	9 3 2
Avrge. for 6 yrs.	100	3·5	55 5	9 9 0
1873	80	2·8	61 3	8 11 6
1874	106	3·7	44 7	8 4 11
1875	78	2·7	46 9	6 4 2
1876	76	2·7	54 8	7 7 7
1877	74	2·6	50 10	6 12 2
1878	108	3·8	40 5	7 13 7
Avrge. for 6 yrs.	87	3·2	49 7	7 9 0

NOTE.—The figures in Column 2 are taken from Mr. Caird's table in his work on the Landed Interest.

The following Papers were read:—

1. *On the Vital Statistics of Sheffield.* *By* THOMAS WHITESIDE HIME, *B.A M.B., &c., Medical Officer of Health, Sheffield.*

The following is a brief abstract of Dr. Hime's paper. He began by describing the physical topography and geography of the town as a necessary introduction to the description of the physical condition of the inhabitants. Sheffield, the sixth town in size and in rateable value in England, is situated on a spur of the Penine range, at the junction of five rivers. The Don, which is the largest, is 144 feet above the sea-level where it flows through the centre of the town. Although handsome public buildings are not a prominent feature in the town, still there are few towns in England where the great bulk of the population is as well provided for in the way of domestic architecture. Overcrowding is very rare, cellar-dwellings are unknown, and almost every family has an entire house, a most important agent in securing physical as well as moral health. Owing to the impervious clay existing below the subsoil, surface wells used to be very common; most of them are closed now, and the water supply is almost exclusively drawn from the Water Company, which has large reservoirs to the west. They are eleven in number, and cover 492¾ acres. The average daily supply is about 17½ gallons per head. High winds are rare, owing to the high escarpments which protect the town on all sides. The prevailing wind in the first quarter of the year is east, in the other three it is westerly, varying towards the north or south. The average temperature of the first quarter of the year is 40 deg. F.; of the third (the warmest), 61 deg. F. The estimated population now is 297,138, showing an increase of 48,031 since the last census. Some of the sub-districts increase little, or even negatively. The population of Sheffield South has fallen off 311 persons, and the Park only grows at the rate of about four persons per annum. According to an old authority, 'by a survaie of the towne of Sheffield made the second daie of Januarie 1615 by 24 of the most sufficient inhabitants there, it appeareth that there are in the towne of Sheffield 2,207 people, of which there are 725 which are not able to live without the charity of their neighbours. These are all begging poore.' In 1801

the population was 45,755, in 1841, 110,891, and in 1861 it had grown to 185,157. The rateable value of the town was 11*s.* 4½*d.* as recorded in some old ratebooks; in 1878 it amounted to 915,888*l.*

The density of the population in general in the borough is only 15·1 per acre. But a large part of the area is wild moorland, never built on, while some parts are closely packed. In Sheffield North there are 257 people living on each acre; in Sheffield West, 89; while in Upper Hallam there are only ·36. The birth-rate is high. During the period 1870–78 it amounted to 40·7 per 1000 living; the highest birth-rate, 41·7, among the twenty largest towns in England, being found in Salford; the lowest, 30·7, in Plymouth. The males born in the whole borough are slightly in excess of the females, but this is not true of each of the sub-districts. The marriage rate is also high. In 1875 it was 22 per 1000 living, while the rate for all England was only 16·8. In 1877 it had fallen to 17·9 per 1000, the rate for all England being 15·8. Last year the death-rate was 24·8 per 1000, or ·4 above the rate in the twenty largest towns, if London be included, during the nine years 1870–78. But there has been a considerable improvement in the mortality of late years. In fact, Birmingham is the only town of equal size which has had as low a death-rate during the past nine years, if London be excluded. Zymotic and local diseases are the most fatal in Sheffield. Hitherto no hospital has existed in the town for the treatment of infective fevers, but the Sanitary Authority is building one which will, when finished, be one of the most complete in the kingdom.

TABLE SHOWING THE RATE OF MORTALITY [1] PER 1000 LIVING FROM ALL CAUSES IN SHEFFIELD AND ITS NINE REGISTRATION SUB-DISTRICTS DURING THE FIVE YEARS 1874–8.

	All Causes				
	1874.	1875.	1876.	1877.	1878.
Borough Total	26·9	24·8	24·3	21·8	24·9
Sheffield, West	29·8	26·4	22·0	21·8	26·9
„ North	27·9	26·8	27·0	26·5	28·3
„ South	30·7	29·0	28·4	23·6	25·7
„ Park	27·2	27·6	31·6	25·0	30·5
Brightside	25·7	24·1	22·0	19·8	21·0
Attercliffe	32·2	25·1	24·5	21·6	26·0
Nether Hallam	24·1	23·1	21·5	19·0	25·0
Upper Hallam	22·0	15·0	20·7	15·3	21·7
Ecclesall Bierlow	24·8	22·8	23·4	21·2	23·7

TABLE SHOWING THE RATE OF MORTALITY FROM ZYMOTIC DISEASES IN SHEFFIELD AND ITS NINE REGISTRATION SUB-DISTRICTS DURING THE FIVE YEARS 1874–8.

	1874.	1875.	1876.	1877.	1878.
Borough Total	7·0	5·7	5·3	4·0	6·4
Sheffield, West	7·9	5·4	4·3	4·5	6·1
„ North	6·9	6·4	5·7	5·8	8·5
„ South	8·9	8·6	5·7	4·2	5·4
„ Park	8·4	6·3	10·3	6·4	9·5
Brightside	6·8	5·0	4·5	3·4	4·7
Attercliffe	9·9	6·0	5·9	3·4	7·7
Nether Hallam	5·0	5·0	4·4	3·3	6·2
Upper Hallam	7·2	1·9	7·4	2·7	4·8
Ecclesall Bierlow	6·1	5·4	4·7	3·2	5·6

[1] After distribution of the deaths in public institutions.

The above tables show the death-rate from all causes and from zymotic diseases in Sheffield, and also in each of its registration sub-districts during the past five years.

On the next table will be found arranged the eleven largest towns in England. They are placed in order in accordance with the place they occupy with reference to some of the more important signs of salubrity. From the table it will be seen that Sheffield does not take an unfavourable place.

THE ELEVEN LARGEST TOWNS IN ENGLAND ARRANGED ACCORDING TO BIRTH RATE, DEATH RATE, ZYMOTIC RATE, AND DEATHS UNDER ONE YEAR TO 1,000 BIRTHS DURING THE NINE YEARS 1870–78.

Birth Rate	Death Rate	Zymotic Rate	Diarrhœa	Deaths under 1 Year
Salford . 41·7	Liverpool . 29·4	Liverpool . 6·57	Salford . 2·02	Liverpool . 222
Birmingham 40·8	Manchester 29·4	Salford . 6·08	Leeds. . 1·95	Leeds . . 195
Leeds. . 40·8	Salford . 27·2	SHEFFIELD 5·70	Manchester 1·86	Bradford . 191
SHEFFIELD 40·7	Newcastle-upon-Tyne 26·5	Birmingham 5·38	Birmingham 1·82	Manchester 190
Newcastle-upon-Tyne 40·3	Leeds. . 26·4	Manchester 5·35	Liverpool . 1·79	Salford . 186
Manchester 39·9	SHEFFIELD 25·5	Leeds. . 5·24	SHEFFIELD 1·69	Nottingham 184
Bradford . 38·9	Bradford . 25·2	Newcastle-upon-Tyne 4·83	Newcastle-upon-Tyne 1·42	Newcastle-upon-Tyne 181
Liverpool . 38·5	Birmingham 24·7	Bradford . 4·43	Nottingham 1·38	SHEFFIELD. 179
Bristol . 36·0	Nottingham 23·7	London . 4·08	Bradford . 1·35	Birmingham 177
London . 35·7	Bristol . 23·6	Nottingham 3·81	London . 1·01	Bristol . 162
Nottingham 34·0	London . 23·0	Bristol . 3·74	Bristol . 0·86	London . 160

From the following table more details can be ascertained as to the sanitary condition of Sheffield, actually, and as compared with other towns of a similar size. The table is extracted from one prepared by Mr. N. A. Humphreys, of the General Register Office.

ANNUAL RATE PER 1000 LIVING OF BIRTHS, DEATHS, AND DEATHS FROM SEVEN ZYMOTICS, IN TWENTY LARGE ENGLISH TOWNS DURING THE NINE YEARS 1870–78.

		Estimated Population Middle of 1878	Birth Rate	Death Rate	Death Rate, less Zymotic Rate	Zymotic Rate	Small Pox	Measles	Scarlet Fever	Diphtheria	Whooping Cough	Fever	Diarrhœa	Deaths under 1 year to 1000 Births
Mean of 20 largest Towns		7,269,976	37·1	24·4	19·8	4·61	0·47	0·50	0·90	0·11	0·74	0·58	1·31	174
1	London. .	3,577,304	35·7	23·0	18·9	4·08	0·52	0·50	0·71	0·11	0·79	0·44	1·01	160
2	Liverpool .	532,681	38·5	29·4	22·8	6·57	0·64	0·74	1·35	0·11	0·93	1·01	1·79	222
3	Birmingham .	383,117	40·8	24·7	19·3	5·38	0·41	0·42	1·19	0·20	0·83	0·51	1·82	177
4	Manchester .	360,514	39·1	29·4	24·0	5·35	0·21	0·59	1·03	0·07	0·85	0·74	1·86	190
5	Leeds . .	304,948	40·8	26·4	21·2	5·24	0·20	0·46	1·13	0·07	0·64	0·79	1·95	195
6	SHEFFIELD .	289,537	40·7	25·5	19·8	5·70	0·46	0·40	1·53	0·08	0·63	0·91	1·69	179
7	Bristol . .	206,419	36·0	23·6	19·9	3·74	0·23	0·46	1·08	0·07	0·51	0·53	0·86	162
8	Bradford .	185,088	38·9	25·2	20·8	4·43	0·10	0·46	1·14	0·09	0·60	0·69	1·35	191
9	Salford . .	170,251	41·7	27·2	21·1	6·08	0·61	0·82	0·95	0·09	0·87	0·72	2·02	186
10	Nottingham .	165,267	34·0	23·7	19·9	3·81	0·44	0·28	0·60	0·04	0·33	0·74	1·38	184
11	Newcastle-upon-Tyne	144,570	40·3	26·5	21·7	4·83	0·73	0·26	1·11	0·08	0·54	0·69	1·42	181

The distribution of deaths among the various trades of the town is a subject

which is deserving of the greatest attention. The table exhibiting the average age at death during 1862–71, and embracing 10,000 deaths, reveals many remarkable facts. There is some reason to believe that the mortality among grinders is not so excessive as it was, though it is still very high. According to the table it was in 1862–71 44 years; from the tables for 1878 it was 47·3.

The following table contains the particulars of the number of deaths, and the average age at death among various classes of workmen in Sheffield during the year 1878, and also the numbers dying at certain groups of ages. A few years ago it was currently believed that a grinder aged above fifty was a curiosity in Sheffield. But we see from the table that thirty-eight died over fifty years of age in 1878, or 45·2 per 100 of the total number of deaths.

AVERAGE AGE AT DEATH, AND NUMBER OF DEATHS IN VARIOUS TRADES IN SHEFFIELD IN THE YEAR 1878, AND DURING THE EIGHT YEARS 1864–71.

Occupations	Ages at death. 1878									1878		1864–71	
	Under 20	20–30	30–40	40–50	50–60	60–70	70–80	80–90	90 and upwards	Total deaths	Average age at death	Total deaths	Average age at death
Grinders	3	9	16	18	20	13	5	0	0	84	47·3	729	44
Cutlers	2	8	11	7	10	9	3	3	0	53	48·0	881	48
Forgers	0	8	8	5	10	9	8	0	0	48	50·5	320	49
File-cutters	2	13	13	11	9	4	2	1	0	55	42·1	423	45
Book-keepers and Clerks	0	7	4	0	5	2	1	1	0	20	43·8	—	—
Colliers	0	1	1	1	0	1	1	0	0	5	51·0	181	—
Soldiers	1	4	3	1	2	0	0	0	0	11	34·9	107	34
Butchers	0	3	3	2	1	2	3	1	0	15	49·8	113	48
Publicans and Beer-house Keepers	0	0	3	2	3	0	0	0	0	8	45·9	139	50
Shoemakers	0	0	2	2	5	4	6	2	0	21	61·7	220	56
Bricklayers and Masons	0	3	3	8	6	3	2	0	0	25	48·8	—	—
Tailors	0	0	1	2	2	8	5	1	0	19	63·5	168	52
Silversmiths and Platers	0	1	2	3	0	1	3	0	0	10	50·2	190	52
Joiners and Cabinet-makers	0	1	3	4	7	8	2	1	0	26	55·0	203	49
Painters	0	4	3	3	6	4	3	0	0	23	49·1	78	43
Labourers	6	19	27	28	25	35	14	4	0	158	49·0	1243	46
Total	14	81	103	97	111	103	58	14	0	581	48·9		

Among the local diseases those affecting the lungs are the most fatal, owing to a large extent to the nature of some of the trades of the town. During the ten years, 1851–60, disease of the lungs amounted to 4·247 per 1000, and during 1862–71 to 4·867 per 1000. Phthisis, or consumption, a disease very fatal in Sheffield, is not included in this. During 1851–60, 3·061 per 1000 fell victims to consumption, a rate which is ·364 in excess of the average for all England and Wales. The presence of silica and iron has been demonstrated in the lungs of persons much exposed to the dust of grinding and stone cutting. Meinel found an excess of from 30 to 50 grains as compared with the lungs of those who were not exposed to the danger of dust. If hygienists believe that fevers are preventible, which are caused by an invisible, unknown agent, surely we should be able to diminish the terrible mortality among stone cutters and grinders, the cause of which may be seen and felt and tasted, as it hangs suspended in the air they breathe for hours every day in earning their bread. Why many workers, at trades of entirely different character, should have exactly the same average age at death is a problem which is deserving of attention. Why should policemen have such very bad lives, an average of only 41 years, the same as the bricklayer? Of 107 soldiers who died

in Sheffield, the average age at death was only 34, the same as among rollers, though the former are enlisted in the prime of life, are well fed, housed, and clothed, and have easy work, while the latter live under very trying conditions. During the past five years 2004 persons have been buried in Sheffield without any certificate from a properly qualified medical man as to the cause of death. This is done, no doubt, in accordance with law, but it is undoubtedly a law which calls loudly for amendment. Another great defect in our sanitary legislation is the want of a registration of disease. An epidemic has often made considerable progress in the town before the Sanitary Authority becomes aware of its existence, the first intimation of which may be the return of the death of some victim. The great and laudable energy displayed in getting children into school nowadays renders it imperative that the master should be aware where the infective diseases exist, and the brothers and sisters of children suffering from such disease should be rigidly excluded from school until there is proper certification that they can return without danger to themselves or others. It is a cruel and unjustifiable thing to compel children to come to school, and, as at present, take no precaution to see that their life or health is not the penalty. Indeed, the schooling arrangement should be in other respects also supervised by proper medical authorities, seeing that a School Board has such power for good or evil over the physical health of a large part of the population in the tender years of growth. The lighting, ventilation, and warming of the schoolroom, the construction of the seats, the colouring of the walls, the age for schooling, and the hours of attendance, are all alike subjects on which every School Board should have the advice of skilled and experienced medical men. The hygiene of the sight of school children is in itself an all-important subject not to be lightly considered. The common employment of rough opaque glass for schoolroom windows, by which much light, so necessary for life, is excluded, and any accommodation of the eyes for distant vision during school hours is prevented, cannot be too earnestly deprecated. By means of gymnastic exercise much might be done to promote the bodily vigour of the children. It should be impressed on every child that the most important knowledge it can acquire is how to maintain the body in health and vigour. This is a necessary condition for the acquisition of a sound education and for the full enjoyment of life. It is to be hoped that the time is near at hand when hygiene will be a compulsory subject in every school, and that at least as much time will be devoted to the study of the living body, and how to maintain it in health, as is given to the study of dead languages and of inert matter. Sickness is the fruitful parent of poverty and crime. The miseries it entails are worse than war or famine; its victims are infinitely more numerous. But there is reason for anticipating that the great increase in the value of life, and the steady decrease in mortality which has been witnessed even within a comparatively short time, will be more marked still in the future, as our knowledge and scientific methods of research become perfected.

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2. *On the Savings of the People as evidenced by the Returns of the Trustees' and Post Office Savings Banks. By* Professor Leone Levi, *F.R.G.S., &c., &c.*

In my last report to Mr. Bass, M.P., on the earnings of the labouring classes, including labourers and artisans, their total amount in 1878 was estimated at about 422,000,000*l.*, of which 350,000,000*l.* was in cash, and 72,000,000*l.* in board, lodging, clothing, and other perquisites. The wages were somewhat higher in 1878 than in 1866, when I made a similar estimate, though considerably lower than in 1872 and 1873. Yet the total amount of earnings was not greater, as the stagnation in trade reduced the number of labourers and the number of days they were actually earning wages. The difference in wages to the working men of the United Kingdom between prosperous and bad times was upwards of 50,000,000*l.* per annum; and it is interesting to ascertain how far our labouring classes have as yet learned to set aside something for a rainy day. In the three years from 1871 to 1873, when wages rose at least twenty per cent., and in some cases forty and fifty per cent., the

labouring classes received in hard cash some 70,000,000*l.* per year, or a total of 210,000,000*l.* more than the normal amount. The cost of living, however, increased during those three years; a rise of wages was not all gain to the working man, for the cost of production increased, and higher prices had to be paid for food, rent, and every enjoyment. That rise was estimated at ten per cent.; therefore 105,000,000*l.*, were required for the increased cost of living in the three years. Allowing five per cent. more for a legitimate increase of the comforts of life in times of prosperity, or 42,500,000*l.* in the three years, or in all 147,500,000*l.*, there still remained 63,000,000*l.* which should have been saved and stand now to the credit of the labouring classes in some form or other. Since 1872 wages had suffered a considerable fall, yet even now in many occupations the wages were liberal, and, with the lower prices of many articles of consumption, there might be room for saving something if only a sense of economy and proper management prevailed in the households of the working population; for at least the half of the last eight years, wages were most liberal, and afforded ample room for saving a handsome amount. What trace of these savings did they find stored in the Savings Banks? The account of the savings in 1870 and 1878 stood as follows:—In 1870 Trustees' Savings Banks 37,958,000*l.*, Post Office Savings Banks 15,099,000*l.*—total 52,987,000*l.*; in 1878, Trustees' Savings Banks, 44,293,000*l.*, Post Office Savings Banks, 30,412,000*l.*—total 74,705,000*l.* Thus the Savings Banks in 1878 possessed 21,700,000*l.* more than in 1870. Deducting 14,000,000*l.* for interest, there remained 7,500,000*l.* saved in this form out of all the extra wages in the eight years. It cannot be said that what was saved in 1873 had been since lost and withdrawn; for the accounts showed that in the totals there had been no going back, but only a slow progress, as shown by the following table:—

	England and Wales	Scotland	Ireland
1870	£46,229,000	£4,132,000	£2,696,000
1878	64,433,000	6,726,000	3,546,000

This was an increase of twenty-four per cent. for England and Wales, fifty per cent. for Scotland, and thirty-two per cent. for Ireland. The results of the last eight years were therefore most favourable to Scotland and Ireland, the next to England and Wales. Comparing six agricultural—Bedford, Buckingham, Cambridge, Hereford, Oxford, and Essex, with six manufacturing districts—Lancaster, Yorkshire, Warwick, Durham, Northumberland, and Gloucester, it will be found that the savings of the manufacturing districts had increased forty-eight per cent., and the agricultural seventy-one per cent.; but in large towns there were many other ways of saving, and that may account for the difference in the percentage.

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3. *On the Assimilation of the Law in England, Scotland, and Ireland as to the care of Lunatics and their Property.* *By* W. Neilson Hancock, *LL.D., M.R.I.A.*

The report of the Irish Lunacy Inquiry Commission disclosed the startling fact that the neglected lunatics have increased from 1,500 to 3,000 in the last twenty years. This had arisen in part from the non-extension to Ireland of the English Act of 1853, and in part from the non-extension of the provision of the English poor-law order of 1844 allowing out-door relief to be given on account of mental infirmity not only of the head of a family, but of any dependent member of it. A large number of harmless lunatics and idiots were provided for by out-door relief in England. But in Ireland the guardians were prohibited by Imperial statute from giving out-door relief on account of the mental infirmity of the dependent member of a family. In Scotland, paupers suffering from mental infirmity may be supported out of local rates while residing with relatives or boarded with strangers. This was a portion of the famous Belgian system which

had existed for centuries at Ghent. In an equal population for those in asylums and lunatic wards in workhouses, the English figure was 8,636, the Scotch 9,438, and the Irish 11,616. The English boarding-out figure was 1,620, and the Scotch 2,097. Under the power of sending paupers to private asylums 609 were provided for in England. In Ireland there were no paupers boarded-out or sent to private asylums. The adoption of the Scotch law in Ireland would provide for 2,097 boarded-out, the adoption of the English law for 609 in private asylums, or 2,706 in all. Of the Irish 3,000 neglected lunatics 2706 would thus be provided for: it followed that the non-assimilation of the laws was almost the sole cause of the 3,000 neglected lunatics in Ireland being in the state they were in. As to the protection of the property of lunatics, the Scotch Law Commissioners and Scotch Lunacy Commissioners had for years suggested that the County Court judges should have the jurisdiction of appointing care-takers of lunatics' property when of small value. In 1865, the English County Court judges had got this jurisdiction in the case of minors; in 1877, the Irish County Court judges had got it for minors also. In the past session a Bill was brought in by Mr. Ramsey, Mr. Baxter, Sir Graham Montgomery, and Mr. Dalrymple to give the Scotch County Court judges similar jurisdiction as to lunatics. Lord O'Hagan brought in a similar Bill for Ireland, but no Bill was brought in for England. The Scotch and Irish Bills have been printed but not passed. If there was a uniform code as to the whole three kingdoms of the law as to lunatics, this delay in legislation need not have occurred; and such assimilation as this and other branches of law is one of the most effective means of diminishing the block of business in Parliament.

SECTION G.—MECHANICAL SCIENCE.

PRESIDENT OF THE SECTION—J. ROBINSON, Pres. Inst. Mech. Eng.

THURSDAY, AUGUST 21, 1879.

The PRESIDENT delivered the following Address:—

On the Development of the Use of Steel during the last Forty Years, considered in its Mechanical and Economic Aspects.

Much has been written by poets and others of a succession of the Ages of the human race in comparing their degradation with the various kinds of metal, considered metaphorically—thus we have the golden age, the silver age, the age of brass, and the age of iron.

Our own time may very appropriately and literally be described as a branch of the latter age, and be named the age of steel.

In the metropolis of the steel manufacture it would seem fitting that the Mechanical Section of this great scientific association should direct its attention to this wonderful metal, the uses of which are daily becoming more numerous and important.

But it may be said, on the other hand, that as the use of this material is perpetually growing more common, so are discussions as to its manufacture, composition, and characteristics, becoming almost wearisome from their frequency.

Notwithstanding an appearance of truth in this objection to our occupying more time in referring to the subject, I would venture to entertain the hope that a treatment of the question in its mechanical and economic aspects may prove not uninteresting to this meeting.

At the time when railway extension was becoming general, about forty years ago, the use of steel in this country was confined mainly to tools for mechanical purposes, including files and other articles, springs for vehicles, weapons of various sorts, and implements for agricultural and domestic uses; and it is proposed to measure the scientific and mechanical energy brought to bear upon the manufacture and improvement of this metal, by the increase in the number of purposes to which it is applied, and the diminished price at which it can be obtained, as compared with the price at the time of its introduction for constructive works. There are, however, several important exceptions to this method of appreciation to which reference will hereafter be made.

We will take, then, the simplest form in the preceding list, viz., *tool steel*, the price of which for ordinary purposes varied from 50*s.* to 56*s.* per cwt. at the period I have named; and we shall find that the development of the manufacture of steel in general has but little affected this particular material, which is still produced in much the same fashion, *i.e.*, by the use of carefully selected Swedish iron, carburised by exposure in ovens to the heat of burning charcoal, and then recast from crucibles and hammered down to the required size. The result of a somewhat stationary condition of manufacture has been the maintenance of prices at the same, or about the same, level up to the present time.

A superior quality of tool steel has been produced by the adoption of a process

invented by Mr. R. Mushet, in which titanium is introduced in the manufacture, and which dates back to the year 1838–39. This steel is of great endurance when applied to the working of steel and iron of considerable hardness, and its higher price of 140*s.* per cwt. is quite justified by the excellent results obtained from its use, and other steels of similar fine quality are produced by several manufacturers, who make specialities of them.

Some twenty-seven or twenty-eight years ago, Krupp, of Essen, gave an enormous impulse to the application of steel, by his method of producing much larger masses of crucible steel than had previously been possible. He at that time accomplished the casting of an ingot of 'crucible' steel of 50 cwt., a weight then considered incredible, and this was followed up by the production of weldless cast steel tyres in 1852, which led to the very rapid development in the use of his steel for railway tyres, cranked axles for locomotive and other engines, straight axles, and shafts, and parts of machines in general.

It is most interesting to consider the prices of such of these objects as have up to this time maintained similar forms, with the object of ascertaining by the selling price the progress in the scientific and mechanical appliances used for the production of the materials just referred to.

At the time of their coming into use, about twenty-five years ago, the price of cast steel tyres was 120*s.* per cwt.; it is now from 18*s.* to 25*s.* per cwt. The price of forged steel cranked axles was, when first introduced, 15*l.* per cwt.; it is now from 65*s.* to 70*s.* per cwt.

The price of straight axles and shafts was from 40*s.* to 50*s.* per cwt.; it is now from 19*s.* 6*d.* to 23*s.* per cwt.

Now to what do we owe this enormous reduction of price and consequent more frequent and more economic application? The answer must be that, following the initiation of Krupp, our English engineers and men of science set themselves to work to discover and apply new processes for the production and manufacture of this most wonderful metal; and I venture to say that in the whole history of metallurgy, from the time of Tubal Cain downwards, there has been no such progress in invention and manufacture as has been realised by the aid of such men as Mushet, Krupp, Bessemer, Siemens, Whitworth, Martin, Bell, Bauschinger, Styffe, and many others within the period comprised in this retrospect; and our national predilections will perhaps lead us to the opinion that our own country may fairly appropriate a large share of merit for the results achieved.

Another of the uses of steel to which attention may be given is that of the production of cannon of large size.

Efforts had been made by some of our enterprising workers in metal to produce large guns of solid wrought iron; but the processes of heating and hammering were attended with so much difficulty that the attempt was given up. Here again Krupp stepped in, and succeeded, thirty-two years ago, in manufacturing cannon of cast steel, which unhappily have become ordinary commodities with those nationalities who could afford such expensive weapons. Since that time Krupp has produced about 2,000 guns, the heaviest being, when finished, 72 tons (16 inch).

Sir William Armstrong and Sir Joseph Whitworth soon came into the field with guns of their own invention. The former, by adopting the system of iron coils applied externally to a central cylinder; and the latter, by shrinking cylindrical hoops on to a central cylinder made of cast steel.

In the adaptation of the steel manufacture of the cast or crucible steel period to the production of every object demanded by the march of engineering and mechanical science, I need not mention the names of individuals and firms in this town who have shown themselves equal to the task; but I will venture to say that their success has been such as to raise the town of Sheffield to the very pinnacle of fame as producing steel of any, even the highest, quality demanded in the markets of the world.

I must now turn to a name honoured everywhere for the benefits and renown he has brought to his country by his inventions and appliances, developed during the last twenty-four or twenty-five years, in the manufacture of a steel which can be cheaply produced and readily adapted to the requirements of the purchaser. I

am sure the audience will in their minds anticipate the record of the name of Bessemer—a name which will be handed down to posterity in connection with the manufacture of steel as long as that manufacture exists.

Another name which will most deservedly figure in the history of the development of the steel manufacture is one, like that of Bessemer, which has been known not only in that development, but in connection with many other discoveries in physical science—I mean that of Siemens, who, like his compeer, has not only invented processes, but has personally carried them out into practical application. An expression let fall by the latter as President of the Iron and Steel Institute at its meeting last year in Paris, exhibits very strikingly the absence of any other feeling on the part of these two great men save that of the most friendly rivalry.

Speaking of a comparison between the results of steel manufactured by the Bessemer blowing process and the Siemens-Martin open-hearth process, Dr. Siemens said, 'He did not see how the result could be the same. It might be better in the Bessemer process than in the open-hearth for aught he knew, but it could not be the same;' and it seems to augur well for the advancement of science in our day that so little of a contrary spirit is exhibited in the discussions which ensue from time to time upon any improved process either chemical or mechanical, having for its object the production of a better material and at a lower first cost. The name of Robert Mushet may very properly be introduced here as one of our early inventors of the improved processes for the manufacture of steel, and it is gratifying to find that other countries besides England have learnt to appreciate the results obtained by him during so many years of scientific and experimental research.

It is needless that I should do more in an assembly like that before me than refer in the simplest terms to the differences in the processes of manufacture connected with these names.

In that of Bessemer, pig-iron of a selected quality is charged into what is technically called a 'Converter,' a large iron vessel lined with refractory material, into which air can be blown at considerable velocity by suitable blowing machinery. This goes on until the iron is thoroughly exposed to the decarbonising influence of the blast, and the impurities contained in the metal are driven off. When this happens the blowing ceases, and a certain proportion of Spiegel eisen or of ferro-manganese is added to the charge so as to give the required amount of carbon. Blowing recommences, this time only to effect complete mixture of the materials, and then the casting of the ingots takes place of a quality corresponding to the metal selected for the mixtures. A mild steel—or, as it has been called, a pure iron—is the resultant, and it is capable of being worked, welded, and hammered very much as in the case of the purest wrought irons; but it possesses generally a much higher tensile resistance and a greater ductility.

In the Siemens-Martin or open-hearth process, a similar charge of pig-iron of the desired quality—probably hæmatite pig—is put into the bed of a reverberatory furnace of the regenerative system, and the necessary oxidation is produced by adding to the molten mass iron ores, or oxides of iron in proportions ascertained by experience, after which re-carbonisation is obtained by the addition of ferro-manganese or Spiegel eisen as in the Bessemer process.

These processes have been the great factors in that reduction in the cost price, and therefore in the extension of the use of such objects as steel tyres, axles, shafts, rails, &c., to which I have already referred, and which is so striking an instance of the results which our men of science can accomplish by their physical and experimental researches into the means of supplying the wants of our work-a-day world.

I will now draw attention to another product of the steel manufacture which is of immense importance, and which could not have been obtained for ordinary purposes but for the facilities of manufacture arising out of the inventions I have just alluded to—I mean that of steel castings, *i.e.*, castings obtained from the crucible, precisely in the form in which they are to be used in the construction of machinery, just as is the case in ordinary cast iron run from the cupola furnace. This production of castings for engineering purposes is gaining an enormous and rapid development; and when it is considered thati n this metal we obtain castings

of a strength at least three to four times that of the strongest iron castings, the importance of this experimental discovery can scarcely be over-rated.

Nor must I pass over the application of these processes to the production of boiler plates, bridge girder plates, and ship plates, in which, as a result of the greater tensile resistance of such plates (reaching for ordinary uses a figure of about twenty-eight to thirty-four tons to the square inch), the engineer is not only enabled to lighten his structure, but to expect from it greater durability—an expectation not diminished by its greater capability of resisting corrosion, especially where care is taken to exclude manganese from the mixture of the metals employed.

For specific purposes, and where price is not so much an element of consideration as great tensile or percussive resistance, a more costly mode of manufacture has been adopted by Sir Joseph Whitworth, whose attention was probably drawn to the necessity for obtaining such a metal, during the construction of cannon and torpedoes, but which has now been extended to objects of a very varied character. The method of manufacture, which has been in use upwards of ten years, is by casting ingots under very heavy hydraulic pressures, from very carefully selected materials, the result being the production of a metal of enormous tensile resistance, reaching in some instances the high figure of 100 tons per square inch, while at the same time the bubbles and air vesicles which sometimes appear in metal produced in the ordinary methods are entirely or almost entirely got rid of, and the consequent striations and imperfections of internal structure and external surface disappear.

It is hoped that ere long we shall be able to procure in this way cylindrical boiler plates rolled solid from the ingot, much after the fashion in which weldless steel tyres are now obtained, and that the weakening of these plates by the existing necessity for forming horizontal riveted joints may thus be avoided.

It is desirable before closing this, I fear, already somewhat long address, to call attention to the most recent development of the steel manufacture as exhibited in the processes of Messrs. Snellus, Gilchrist, & Thomas, by which iron containing a considerable proportion of say 1·44 per cent. of phosphorus, may, in the course of its manufacture into either Bessemer or Siemens-Martin steel, have this deleterious matter entirely removed, or reduced to an inconsiderable proportion.

The method of carrying out this operation was exceedingly well described at the recent meeting of the Iron and Steel Institute in London, and it was shown that where such irons were melted in vessels lined with a slag having twenty per cent. of silica and thirty per cent. of lime and magnesia, the phosphorus was gradually and effectually absorbed by this lining, and a steel of good quality, comparatively free from phosphorus and silica, was produced.

The result to the community will naturally be that, as henceforth a much more extended area of our iron fields both at home and abroad will become available for the production of steel, the use of that metal will be still further extended and its price reduced mainly by means of the methodical researches of our scientific metallurgists, and entirely independently of those accidental combinations which have in less scientific days led to the adoption of new and improved methods in the production of metals required by the progress of mechanical and economic science.

Since writing the above address two other matters have been brought before me which may, I think, be interesting to this meeting.

One is the specification for the steel to be used in the construction of the great railway bridge over the Forth, the plates for the main girders and braces of which are to be of 'mild steel,' giving a tensile resistance of 26 tons per square inch of section; while for the rivets, not only is the same tensile resistance to be given, but the minimum of elasticity is to be 16 tons to the square inch, and the elongation before breaking not less than 25 per cent.

The bars and rods, which are to be made from 'high-class steel,' are to have a tensile resistance of 40 tons per square inch, and a minimum of elasticity of 20 tons, while the elongation is to be 12½ per cent. before breaking.

It will be seen from these figures that not only will the structure itself be enormously lighter than if materials such as have been hitherto employed for such

purposes had been adopted, but that a considerable increase of durability is anticipated from the chemical and molecular constitution of the metals selected.

The other matter is the fact that a very large order for steel rails for America has been taken by a house of the highest eminence in this country at the price of 4*l.* per ton delivered at the works—a price which is almost astounding to those who have lived long enough to remember the high price at which any quality of steel could be produced in former years, and when a knife with real steel blades was a prize valued because not always attained in the days of our childhood.

It seems to me that these two facts amply illustrate the position taken up at the beginning of this address, as indicating the scientific energy and mechanical enterprise brought to bear upon the production of steel—in the one case by the lessening of its cost, and in the other by a most important extension of its application.

The following Papers were read:—

1. *Temperature of Town Water Supplies.*

By Baldwin Latham, *C.E., M.Inst.C.E., F.G.S., F.M.S, &c.*

The author, in this paper, drew attention to the fact that the temperature of the water-supply of a town, as furnished by public waterworks, was totally independent of the temperature of the water at its source of supply, and that invariably the temperature of water was the temperature of the ground at any season of the year at the depth at which the distributing mains were laid. The average temperatures throughout the year, whatever the source or mode of supply, varied very little, but there was great difference in the range of temperature, and that while the temperature in the chalk wells at Croydon gave an average monthly range, based upon daily observations, of 0·64°, the same water, when supplied direct from the mains, gave an average monthly range of 21·14°, or when stored in a cistern a range of 28·05°; while water supplied from the Thames in Westminster gave an average monthly range of 24·69°, but the average yearly difference of temperature between the chalk water supplied at Croydon and the Thames water supplied in Westminster was only 0·67°.

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2. *On the Quantitative Elements of Hydrogeology.*

By Joseph Lucas, *F.G.S., Hydrogeologist, late of H.M. Geological Survey.*

§ Percolation.

Divisions of the Rainfall Year.—Among observers of percolation Mr. Evans divides the year into the winter half, October 1 to March 31, and the summer half, April 1 to September 30. Messrs. Lawes and Gilbert take the harvest year from September 1 to August 31. Mr. Greaves gives the amount for each quarter, and for the year ending at each quarter—March, June, September, and October. Ebermayer divides the year into four quarters—

Spring . . .	March.	April.	May.
Summer . . .	June.	July.	August.
Autumn . . .	September.	October.	November.
Winter . . .	December.	January.	February.

Giving his annual totals in respect of the twelve months, March—February.

In a paper[1] read at the Meteorological Society, Mr. James Glaisher, F.R.S., supplies materials for comparing these various methods. He shows that the rainfall year divides itself into two halves, commencing March 1 and September 1, thereby proving the sagacity of Ebermayer.

Divisions of the Percolation Year.—The month of March contains the driest ten-day, fifteen-day, and thirty-day periods in the year, and the months of March and April the driest sixty-day period. The effect of this is manifested in the

[1] 'On the Fall of Rain on Every Day of the Year, from Observations extending from 1818 to 1869.'—*Proc. Met. Soc.*, vol. v. p. 87.

complete cessation of percolation in April. There is no such uniformity in the wettest periods of equal duration, and in consequence percolation does not recommence till the close of the longer wettest periods of thirty, sixty, and ninety days. Mr. Evans's soil gauge frequently leaves off recording percolation a month earlier, and begins to record it again a month later, than Mr. Greaves's. Mr. Evans's gauge is filled with a mixture of *gravel, loam,* and *mould,* and Mr. Greaves's of *gravel, loam,* and *sand,* which probably accounts for the difference in this respect.

Characters of the Soil.—The calibre of the constituent grains of the soil, and the percentage of grains of various calibres in the natural admixture, should be known for every soil on which percolation experiments are or have been carried out. In a collection of grains of given calibre spheres will occupy more space than any other shape, or the absorbent capacity is least when the grains are spherical. The space occupied by any number of spheres, from one upwards, which exactly lie in a cubic foot, is ·5236 cubic feet as long as the arrangement is cubical, the retentive power increasing with the fineness of the grains. The natural arrangement is, however, pyramidal, in which one sphere rests in the hollow between four. As more spheres will thus go into a cubic foot the space occupied is somewhat greater than ·5236, and the absorbent capacity somewhat less than ·4764. The absorbent capacity (pyramidal) decreases with the diminishing calibre of the grains.

Diameter	Absorbent Capacity		Diameter	Absorbent Capacity	
	Cubic inches	Cubic feet		Cubic inches	Cubic feet
·333	714·6	·4135	·040	686·7	·3974
·300	709·92	·4108	·03125	686·18	·3970
·250	704·55	·4077	·030	685·84	·3969
·200	700·38	·4053	·020	684·96	·3963
·125	696·64	·4031	·015625	684·28	·3959
·100	691·92	·4004	·010	684·09	·3958
·0625	688·59	·3984	·005	683·66	·3956
·050	687·56	·3979	—	—	—

The *absorbent capacity* is the space available for holding water between the grains of the soil. The *retentive power,* the quantity which the soil can hold by capillarity, increases with the fineness of the soil. The percolative capacity presents three cases:—1. Natural percolation from rainfall. 2. The percolative capacity at retentive point. 3. The percolative capacity under pressure.

Natural percolation depends upon the amount of and difference between the absorbent and retentive power, and so upon the calibre of the soil and the shape of the grains; the quantity of rain falling; the humidity of the soil at the time of the fall; the temperature of the soil, the percolating rain, and the air; and the humidity of the air.

Percolation commences when the degree of humidity of the soil just exceeds the retentive point. The absorbent capacity of a cubic foot of sand of less than ·035 in calibre was 730·8 cubic inches, or ·422 cubic feet, which equals a depth of 5 inches of rain on the square foot; its retentive power 461 cubic inches, which equals a depth of 3·208 inches of rain on the square foot. Such falls of rain in 24 hours are excessively rare, so that the soil is rarely or never saturated. It generally exists in a degree of humidity far below retentive point, so that only the excess over this deposit can percolate. The percolative capacity at saturation point requires to be determined experimentally; also a degree of humidity corresponding to the observed annual average natural percolation. Mr. Evans gives this as 8·227 inches for the 25 years, 1835–1860, which equals a daily transit of 3·24 cubic inches through each square foot. We do not know the average humidity represented by this percolation. Even when the humidity exceeds retention point, percolation sets in and a waterline is formed. The degree of percolation represents the minimum waterline, and saturation point the maximum waterline. Therefore *the degree of humidity, the quantity percolating,* and *the height of the waterline* can be expressed in terms of each other.

The determination of the percolative capacity at saturation point has a practical bearing, as it is probable that the soil is capable of passing twice as much per minute as the average percolation from rainfall in a day. Also, because irrigation sewage works exist on gravel and other soils in which there are wells. The percolative capacity under pressure bears on the yield of wells sunk in sands, &c., near to and remote from large bodies of water upon the surface.

Temperature of Percolation.—The temperature of percolation has not been observed. Changes of temperature in the soil must act upon the contained moisture in the same way as they do in the air above, thereby tending to cause evaporation or to produce percolation. In an abstract of more than 100,000 observations upon the temperature of the soil made in the Gardens of the Royal Botanic Society, London, 1871–1876, Mr. G. J. Seymour, F.R.S., shows that the heat wave commences in March, and spreads downward till the whole 4 feet of observation is warmer than the air in September and October; the effect of the preceding cold was disappearing at 4 feet by the end of August. In November the cold wave commences and moves down till the whole 4 feet is colder than the air by the end of February, when the heat wave begins again. This corresponds with the division of Ebermayer on March 1 as regards the commencement of the heat wave at the surface and the disappearance of the preceding heat wave at 4 feet; and on September 1 as regards the disappearance of the preceding cold wave at 4 feet, *but not as regards the surface*, the heat wave lasting till the end of October. These heat divisions correspond with the 'least rain' periods of Glaisher which occur in February and March, the last two months of the cold wave, and with the 'heaviest rain' periods which end with the heat wave at 3 inches in October; with the cessation of percolation in March (when the heat wave begins) and its recommencement in November (when the cold wave begins).

In reference to future observations on percolation, therefore, it is suggested that:—

1. Artificial admixtures should be avoided.
2. The calibre of the constituent grains, and the percentage of grains of each gauge in the natural admixture, should be experimentally ascertained.
3. The absolute capacity should be measured.
4. The retentive power should be proved.
5. The percolative capacity at saturation point, and as far as possible at less degrees of humidity, should be measured.
6. The percolative capacities under pressure greater than that of saturation should be proved.
7. Percolators should contain thermometers.

There should be a set of three cylinders—A, *the saturated cylinder*, filled with saturated soil, closed top and bottom, and provided with a thermometer.

B a common Dalton gauge, provided with thermometer.

C the dry cylinder, filled with dry soil, closed top and bottom, and provided with a thermometer.

The thermometers should be arranged back to back in the centre of each percolator at depths of 1, 2, 3, and 4 feet, and one at 3 inches and at the surface close to them. Presumably the thermometers in the Dalton gauge would agree with those in the dry gauge when the soil was dry, and with those in the saturated gauge when the soil was saturated, as their difference would be noted. We should then have something more than wet-and-dry bulb thermometers in the soil and the machinery for connecting observations on rainfall, temperature, and percolation, and for comparing different series of observations at present wanting.

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3. *On Léon Francq's Fireless Locomotive.*

By Mons. Charles Bergeron, *C.E.*

The *fireless locomotive*, described by Mons. Charles Bergeron, is an American invention. It has been much improved by Mons. Léon Francq, civil engineer in Paris, who studied the question of mechanical traction by means of steam engines

without fire, that is to say, by means of hot water heated to a high temperature by the injection of the steam into a body of water.

He made a very successful application of his system on the line of tramways between Rueil and Marly le Roi, near Paris, which is in a working order since the month of July of the last year, and never failed nor gave any reason of complaint from the public.

The principal object, namely, the suppression of the furnace of the locomotive, is obtained by the utilisation of the calorific capacity of water, by giving it a quantity of heat sufficient for the production of the steam necessary for the working of each machine during a good length of time. The means adopted consists in causing to pass into a volume of water contained in a closed reservoir placed on the locomotive, a current of steam at high pressure produced in a generator fixed at the departure station, and which gives up its heat in the ratio of its mixture with the water.

The locomotive consists of a large cylindrical reservoir, surmounted by a dome in which the steam is accumulated, and supported by a frame to which are fixed all the mechanical movements similar to those of an ordinary locomotive.

The reservoir holds more than 700 gallons, about two tons of water, which, introduced into the apparatus, should be heated to a very high temperature before the locomotive is put in motion. By the aid of a fixed generator, it is capable of producing steam at a pressure which may attain sixteen atmospheres (224 pounds per square inch), at a temperature of 203° Centigrade.

The steam comes from the generator into the reservoir by a pipe forming a branch with another horizontal pipe placed near the bottom of the reservoir along all its length, closed at its two extremities, but pierced on its upper surface with two lines of small holes.

The steam rushing from the generator escapes through all the holes of that tube and brings the water of the reservoir to the desired conditions of temperature and pressure.

The distribution of steam to the cylinders of the locomotive is not different from similar machines except in its mode of working. The escaped steam is not used to increase the draught, as there is no fire; it forms no clouds of steam issuing from the chimney, and produces no noise in escaping.

The escape is made into an air condenser, formed by a close cylinder traversed by more than 600 metallic tubes which are open at both ends, so that the air may pass freely through them from end to end and keep them cool. The steam after its working is condensed into that cylinder, and the water falls into a small tank placed under the foot-board of the driver.

The principal apparatus of the fireless engine invented by Mons. Francq is the *expansive regulator* (détendeur), by which the steam is carried to the cylinders of the locomotive regularly and at the same pressure.

That pressure may vary from three to eight atmospheres, according to the amount of resistance of the cars running on the tramways.

The spring of a balance, similar to those used for safety valves on boilers, is applied for opening more or less the valve of admission of the steam into the exhaust regulator, and it acts so well that while the locomotive is in work the valve of admission oscillates in almost precise correspondence with the pulsations even of the motive pistons.

The traffic on Reuil and Marly Railway having been carried on by small locomotives of the ordinary type previous to being worked by fireless engines, affords an opportunity of making an exact comparison between them. In regard to consumption of fuel, the account shows an important advantage in favour of the fireless engine. The boiler of a locomotive is much more expensive on account of its brass tubes in construction and in maintenance.

The books of the company prove that the ordinary locomotive costs 41 francs 39 cents, and the fireless engine only 22 francs 77 cents, nearly the half, for a run of 102 kilometres every day.

The tubes in the boiler of the ordinary locomotive last six or seven years, and

the boiler requires expensive repairs frequently; the reservoir of a fireless engine will last thirty years, and will require hardly any repair.

The fireless locomotive possesses all the elements of safety that can be required in an engine intended to run in the streets of towns and along country roads.

Explosion is impossible; there is no firebox to be damaged; no hot cinders can be thrown into the fields. There is no firelight to alarm—no steam escaping from valves, no whistle, nothing to frighten the most timid animal, as in ordinary engines. There is no smoke; neither the passengers nor the travellers on the road can be annoyed by the sulphurous fumes of burning coke, or smothered with coal smoke. There is no soot to blacken the linen and clothes of passengers, nor to soil the carriages inside or out. There is no flame rising from the smoke pipe, or hot cinders or ashes to burn passengers' clothes. There is no disagreeable smell of burning coal or oil, and the traction is more easy and more pleasant than even that of horses.

Fireless locomotives have worked the traffic on the Rueil and Marly Railway, and are still working it now, with a perfect regularity, from the early part of July 1878.

They never had any accident nor stoppage on the road, even during the severe winter of this year. Their weight, when empty, is *six tons*; they contain two tons of water when they start from Marly, where is the feeding boiler always in fire. The steam in the reservoir is at a pressure of fifteen atmospheres at the departure, and only four atmospheres at the return, after a run there and back of fifteen kilometres, nearly ten miles. The weight of steam drawn from the reservoir for working the engine is only 200 kilogrammes ($\frac{1}{16}$ of its first volume).

It requires about twenty minutes to replace those 200 kilogrammes by the same weight of steam drawn from the feeding boiler.

When the pressure in the reservoir of the locomotive is the same as in the fixed boiler, the engine is fit for working, and may wait several hours without a sensible loss in the pressure of its steam.

The engine can run with four or five tramway cars. The number of passengers varies from 60 to 250 per train.

These fireless locomotives have worked the traffic of the Rueil and Marly Railway for more than one year. They run regularly at half-hour intervals from 6 a.m. to 12 at night. The service has given general satisfaction to the passengers, to the inhabitants along the line, and to the railway company. It may be concluded therefore that the fireless locomotive of Mons. Francq is not only an elegant and simple engine, but it possesses incontestable advantages in point of economy, and probably will solve the important problem of a mechanical power applied to the working of short lines of railway along roads and of tramways in towns.

FRIDAY, AUGUST 22, 1879.

The following Papers were read:—

1. *On Self-acting Intermittent Syphons and the Conditions which determine the commencement of their Action.* *By* ROGERS FIELD.—See Reports, p. 223.

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2. *On recent advances in Electric Lighting.*
By JAMES N. SHOOLBRED, *B.A., Mem. Inst. C.E.*

Twelve months ago electric lighting, in its application at least, was hardly known in England, except in connection with a few lighthouses; now there is scarcely a large town in the United Kingdom where this light has not been

publicly tried, in the illumination either of out-of-door spaces or streets, or of the interior of public buildings or industrial works of various kinds. Since last year[1] many improvements have taken place, both in the machines for the generation of the electric current, and also in the burners for utilising it. The actual requirements of practice, and especially the improved gas illumination in London and in Paris, showed that electric lights of a more moderate illuminating power were needed than were those afforded by the single-light machines of Siemens and of Gramme. To the subdivision of the electric current for the production of an increased number of light-centres of moderate illuminating power, and to a more economical form of burner, especially in the form of a 'candle' instead of the more delicate and expensive 'regulator,' has the attention of electricians been especially directed.

In the type of 'Gramme' machine used so far with the Jablochkoff candles both in France and in this country, two separate machines have been required; an 'excitor' to generate the current, to be passed on to the 'light' machine for subdivision into several distinct circuits. In the new form, though these two parts are still separate, they compose but one machine; which by a suitable arrangement of the circuits may be made to support, with an expenditure of the same amount of motive power, either the same number of lights as formerly, or, at will, the number may be increased while luminosity of each is diminished, till the total number of the light-centres is double that of the older machines; while the aggregate of the illuminating power remains about the same throughout. Thus, within the writer's personal experience, a machine of the new type, which contained the same amount of copper and iron as the old four-light machines, and absorbing about the same amount of motive power, viz. $4\frac{1}{2}$ horse-power (net), could be made to produce either four lights of nearly 600 candles each, or ten lights of about 240 candles. A larger machine of similar construction could, it was understood, feed, either eight of the large, or twenty of the small lights, with an absorption of rather under 10 horse-power. With the large lights, and the older type of machine in use on the Thames Embankment, twenty lights require a net expenditure of nearly 20 horse-power.

With the Lontin machine an improvement in the same direction has taken place; the six-light machine of last year now producing twenty-four lights, each of illuminating power somewhat similar to the small-sized lights just referred to. In the De Meritens machine a somewhat increased productive power is the result of a considerable simplification, and consequent economy, in the form of the steel magnets employed.

A new form of generator has entered the lists in the Thermo-electric pile of M. Sudre, erroneously called by some the Clamond, from a former pile of this name. The 'Sudre' pile is a cylindrical hot-air furnace placed vertically, having on its outside two sets of small flues, formed in cast-iron chambers; and outside of these a series of electric chains hang vertically, and are composed of small cubes of an alloy of zinc and antimony, connected with each other by strips of tin, while exterior to the cubes, and radiating from them, are placed vertically, like the leaves of an open book, thin sheets of copper. The hot air from the top of the furnace is forced downwards through one set of chambers, and up again through the outer set, heating in its passage the zinc cubes which are placed against the flue, a strip of asbestos only intervening; while the copper plates act as the distributors of the heat so acquired; the difference of temperature between the heated back of the zinc cubes and the outer edge of the copper plates being about 3 to 1. A double pile of this construction, containing 3,000 zinc cubes or elements in each half, in use in Paris for some months back, has a total electro-motive force of 218 volts, which is equivalent to 120 Bunsen cells, and has a total resistance of 31 ohms. This pile works two Serrin lamps very steadily and noiselessly, each giving a fair moderate-sized light. The fuel consumed with the pile is coke; about $1\frac{1}{2}$ hours and 30 lbs. of coke being required to raise it to the required temperature, after which 20 lbs. is the hourly consumption.

[1] See 'Present State of Electric Lighting,' in *Minutes of Proceedings of the British Association*, Dublin Meeting, 1878.

In electric burners, Messrs. Siemens have lately brought out a 'pendulum' lamp, which differs very materially from their previous forms of regulator and from others of the same class, by dispensing with a large amount of the clockwork. In it the separation and approach of the carbons necessary for lighting is effected by the in-and-out movement of a plunger within a solenoid; the motions of the plunger being communicated by means of a hinged frame to the upper carbon holder. When the motion of the plunger is not sufficient for the feed of the carbons, the holder-rod, which has a rack on one face in its lower portion, becomes detached from the frame, and continues its descent by gravity. The rate of descent is, however, rendered regular by a pendulum fixed on the same shaft as the toothed wheel fitting into the rack; thus the descent of each tooth of the carbon-holder rack corresponds to a beat of the pendulum.

Mr. C. Heinricks has introduced a 'regulator,' which presents many points of difference from the other lamps distinguished by that name. A small case compactly encloses the entire of the controlling apparatus, which acts upon a shaft beneath, but entirely outside of it; upon this shaft are placed the holders of the two semi-circular carbons, which fall by gravity as required to a point immediately beneath. By this arrangement the light is left free and unrestricted for projection away from the lamp; while the circular form of the carbon pencils permits of a much greater duration of uninterrupted illumination than would be the case with straight carbon-pencils, within the same space. The controlling mechanism includes two distinct magnets and armatures; one for the feed, the other for the separation of the carbons. By an ingenious arrangement the alternate action of these two magnets is made to control the approach of the carbons, which becomes a step-by-step movement, instead of an unchecked continuous one. To this last are ascribed, by some, many of the interruptions in the light, as well as the subsequent hissings which are found to occur with the ordinary forms of 'regulator.'

Much attention has of late been directed to the more economical form of burner termed 'candle,' from the two carbon-rods being placed side by side, and both being consumed at the same rate. The only type in use twelve months ago was the Jablochkoff candle. In its original form it possessed the disadvantages of having the carbons rigidly fixed, so preventing any self-adaptation to the variations of the strength of the electric current, and without any power of relighting itself if once extinguished. This last property has since been acquired by the introduction of some zinc filings into the insulating substance: an improvement which does not appear, however, to be much made use of.

The De Meritens candle dispenses altogether with the insulating substance, and its inconvenience of manufacture; one, or even two, insulated carbon-rods taking its place, and causing induced currents in them during the passage of the current from one outside main carbon to the other. A form of 'candle' known as the Wilde, but first devised by Rapieff, is superior to the preceding ones in simplicity, efficiency, and economy. In it the carbons are placed in two separate holders, one fixed and the other responding to the movements of the armature of a magnet, through which the current passes. The Jamin candle, about the merits of which much has been said of late, has the two carbons fixed, without any insulating substance between them. The wire from one of the carbon holders, instead of passing directly away, is before doing so wound vertically round the candle in the plane of the two carbons, and at a distance of about $\frac{3}{4}$ inch from each of them; about five turns are taken, each insulated from the other, and all formed into a single coil. Heinricks has a candle with two pairs of semi-circular carbons, at right angles to each other, and with an electro-magnet above controlling them.

To these improvements in the electrical apparatus themselves must be added those in the delicate automatic governing gear of the engine-motors, both steam and gas, in order to insure that extreme regularity of motion which is requisite for electric illumination. Of these, in steam engines, among the most successful are those of Ransomes, Sims, and Head, of Duvergier (of Lyons), of Robey, &c. While in gas engines, the most extensively used, so far, is the 'Otto' of Crossley Brothers; though L. Simon and Son, and also Clerk, have each more recently introduced engines which present ingenious and novel features.

3. *On the Changes of Volume in Iron when passing from the Liquid to the Solid State, and an Instrument for observing the same.* *By* T. WRIGHTSON, *Memb. Inst. C.E., F.G.S.*

That there are some considerable changes in the density of iron in passing from the solid to the liquid state, is best illustrated by observing the behaviour of a piece of cold iron when thrown into a ladle of molten iron. After being thrown in, it rises to the surface, and as it becomes heated continues rising out of the metal until a considerable portion of its bulk is raised above the molten surface. It then appears for a time to remain without further change of volume until it reaches the melting point, when it rapidly subsides into the general mass.

These phenomena appeared to the writer to be well worthy of examination; the more so because much has been written upon the apparent anomaly that, although iron when cast in a mould contracts in all its lineal dimensions about one per cent., and should therefore, when cold, have a specific gravity higher than that of liquid metal, it nevertheless floats on the surface when thrown into the molten iron.

All kinds of ingenious explanations have been hazarded to account for this, but no one appears to have taken the precaution to ascertain whether the anomaly was real or only apparent.

In order to exhibit the changes of specific gravity during the passage of the iron from the solid to the liquid state, it occurred to the writer to submerge a ball of cold iron in a vessel of molten iron to a certain depth, and to connect this ball by means of a rod of refractory material to a spring balance; any expansion or contraction of the ball would cause a greater or lesser displacement of the liquid iron, and the variation of buoyancy produced by this could be read off in ounces on the index of the spring balance.

A spring balance, with a circular dial plate, was accordingly suspended on a wooden framing immediately above a large vessel of molten iron. A rigid rod weighing two or three pounds was fastened to the moving slide of the balance, and to the end of this rod was attached the cast iron ball to be experimented upon. Before fixing the ball, the position of the index of the balance was marked in pencil on a sheet of paper, surrounding but not covering the circular face of the dial. The ball then being attached, another pencil mark, farther round the dial, indicated the whole weight of the ball and rod, and one indication subtracted from the other represented the actual weight of the ball.

Now if the specific gravity of the cold ball were exactly the same as that of the hot metal, there would be no tendency when the ball was lowered into the metal either to sink or swim, and in that case the pointer would travel back exactly to the mark, showing the weight of the rod alone. If the ball were of higher specific gravity there would be a sinking effect which would prevent the pointer arriving at this mark, the space it fell short representing this sinking effect. As the ball expanded in volume it would displace more liquid metal, producing an upward flotation equal to the difference between the weight of the ball and the weight of the fluid displaced, and which, so long as the ball continues of the same weight and is not allowed to rise to the surface, can be read off in ounces on the dial plate while the operation proceeds.

By carrying out this plan the author obtained an exact register of the successive alterations in volume taking place in the ball, though hidden from sight below the surface of the metal.

Immediately the ball was immersed and held two inches below the surface, an assistant called out intervals of seconds, while the writer marked on the paper round the dial plate the corresponding positions as the movement of the pointer took place. After obtaining indications of various sizes of ball, the results were laid down graphically.

In the diagrams thus obtained we have a complete record of the changes in volume and specific gravity from the cold solid to the commencement of the molten state.

An examination of the results obtained shows that in all cases there is a sinking effect when the ball is first submerged; in a few seconds this disappears

and gives way to a floating effect. From this it appears evident that cold cast iron sinks when first put in a bath of molten iron, and that therefore its specific gravity is higher than that of the liquid metal, and that its rapid expansion displacing the liquid metal, and causing it so quickly to come to the surface, has led to the widespread but erroneous belief in the anomaly described. This has been proved by the writer in a more direct way, by making a number of spheres of cast iron, 1, 2, 3, 4, and 5 inches in diameter. These when cold were lowered (not thrown) into the molten iron by means of a bent iron fork, the ball resting freely on the two prongs of the same.

In *every* case the ball went down with the fork, rested under the metal for a few seconds, and then rose to the surface, the experiments being confirmatory of the results obtained with the apparatus already described.

The diagrams also show that the line showing change of volume continues to rise in a somewhat irregular curve until it reaches its maximum above the line of equilibrium. The further increase of heat then appears to have little effect in changing the volume of the ball, as the line of volume remains in its maximum position until melting commences, when the ball rapidly subsides.

The table accompanying this shows the maximum variations of sinking or floating effect in percentages of the actual weight of the balls, also the actual floating or sinking effect in ounces avoirdupois.

Diameter of ball	Weight avoirdupois	Maximum sinking effect		Maximum floating effect	
		Weight avoirdupois	Percentage of whole weight	Weight avoirdupois	Percentage of whole weight
	oz.	oz.		oz.	
3 inch, 1st Experiment	58½	2	3·4	7½	12·8
3 „ 2nd „	59¾	2¾	4·6	5¼	8·8
4 „ 3rd „	132¾	2¼	1·7	13½	10·0
4½ „ 4th „	182¾	2¼	1·2	13¾	7·5

From the above it will be seen that the volume of the ball in the first experiment varies from 3·4 per cent. below, to 12·8 per cent. above the volume of equilibrium, being a total change between the extremes of 16·2 per cent. This is the highest result; for the lowest it will be found that the 4½ inch ball (fourth experiment) has a variation of 7·5 per cent. above, and 1·2 per cent. below, or a total variation of 8·7 per cent.

The diagrams read the reverse way should furnish an indication of the change in passing from the liquid to the solid; and the author describes phenomena observed in the cooling of iron castings, which confirm this view.

The following conclusions may be inferred from these experiments:

That when in the solid state cast iron is at its greatest density.

When in the plastic state, immediately before liquefaction, it is at its least density.

That the liquid state is intermediate in density, being much nearer in degree to the solid than to the plastic condition.

The writer is now completing the construction of a more elaborate instrument to effect the object he has in view. The index of the spring balance is made to move vertically in a straight line. A pencil attached to the index presses on a piece of paper coiled round a cylinder five inches in diameter, which revolves on a vertical axis by means of clockwork, arranged so that the surface of the paper on the cylinder moves at a uniform speed, while the pencil follows the change of volume in the ball of metal under examination. A much more accurate diagram should by this means be formed than has been possible by the means at first adopted by the author.

Note.—For a more complete account of these experiments see a paper by the same author on 'Some Physical Changes in Iron and Steel at High Temperatures,' read before the Iron and Steel Institute at Liverpool, September 1879.

SATURDAY, AUGUST 23, 1879.

The Section did not meet.

MONDAY, AUGUST 25, 1879.

The following Reports and Papers were read:—

1. *Report of Committee on Instruments for Measuring the Speed of Ships.* See Reports, p. 210.

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2. *Report of Committee on the Ordnance Datum.*—See Reports, p. 219.

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3. *Report of Committee on Tidal Observations in the English Channel, &c.* See Reports, p. 71.

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4. *Report of Committee on the Patent Laws.*—See Reports, p. 223.

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5. *General Results of Experiments on Friction at High Velocities made in Order to Ascertain the Effect of Brakes on Railway Trains. By* Douglas Galton, *C.B., D.C.L., F.R.S.*

The experiments were made on the Brighton Railway, with the assistance of Mr. George Westinghouse, with a special four-wheeled van constructed for the purpose; it was attached to an engine, and was run at various speeds, during which time various forces were measured by self-recording dynamometers. The principle of these dynamometers is that the force to be measured acts on a piston fitting in a cylinder full of water, and the pressure of the water is measured by a Richards indicator connected by a pipe to the cylinder; thus, as the drum of the indicator revolves, diagrams are obtained, giving the force acting on the piston. The advantages of this method are obvious, because the indicator can be placed at any convenient point, and the inertia of the water tends to make the pencil keep a position corresponding to the mean force. A detailed description of the construction of the dynamometers was given to the Section last year, and on this occasion the results arrived at alone will be stated.

In most of the experiments the tyres were of steel, and the brake-blocks of cast iron. Some experiments were made with wrought iron blocks, but the results were not uniform or satisfactory.

It will suffice here to give the general results arrived at.

It is convenient in looking at the question of railway-brakes to consider first, what is the operation of a brake?

A train, through the adhesion of the wheels of the locomotive acting on the rails, slowly accumulates energy, and for each ton of weight in the train the accumulated energy is equal to 120 foot-tons at 60 miles per hour, 53 foot-tons at 40 miles per hour, and 30 foot-tons at 20 miles per hour. Thus, for a train of fifteen vehicles, weighing 200 tons, the energy at 60 miles per hour is equal to 24,000 tons falling a distance of one foot.

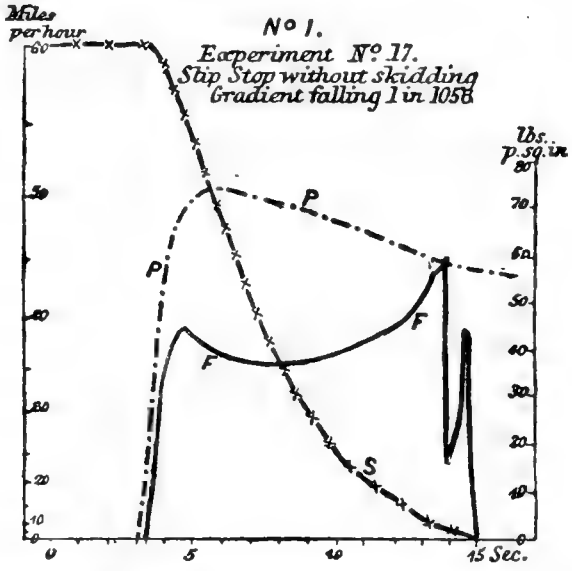
After a train has attained the desired speed, the reasons for stopping it may be of two kinds: (1) at prearranged places for convenience; and (2) for the prevention of accidents or for mitigating the consequences if accidents are unavoidable.

To stop a train for the first reason requires but a limited amount of force, which may be applied in any crude manner.

For the prevention of accidents, however, there is required:—

a. The instantaneous application of the greatest possible amount of retarding force.

b. The continuous action of this force until the momentum of the train is destroyed.



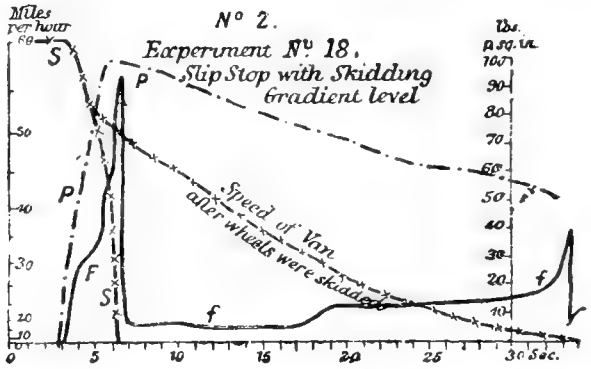
The retarding force used in practice is that due to the friction resulting from the forcible application of pieces of metals or wood (brake-blocks) to the tyres of the wheels; this friction impedes the rotation of the wheels, and tends, through the adhesion of the wheels to the rails, to destroy the energy stored in the train. The retarding force is therefore limited to the resistance obtainable between the wheels and rails.

It was at first customary to attach to a train, for purposes of retardation, a certain number of vehicles with extra weight, to which the brakes were applied; but since the question of retardation has become better understood, brakes have been applied to every vehicle, the means of applying these brakes being placed in the hands of both the engine-driver and the guard. The reason for this is that the maximum amount of retarding force can be obtained only by applying brake-blocks to every wheel in the train, each block being pressed with sufficient force to produce a resistance to the rotation of the wheel just equal to the greatest possible friction between the wheel and the rail. This greatest possible friction occurs when the adhesion of the wheel to the rail is just about to be overcome by the superior effort of the brake-blocks, which effort, if further increased, immediately begins to stop the rotating movement of the wheel, and thus causes it to slide

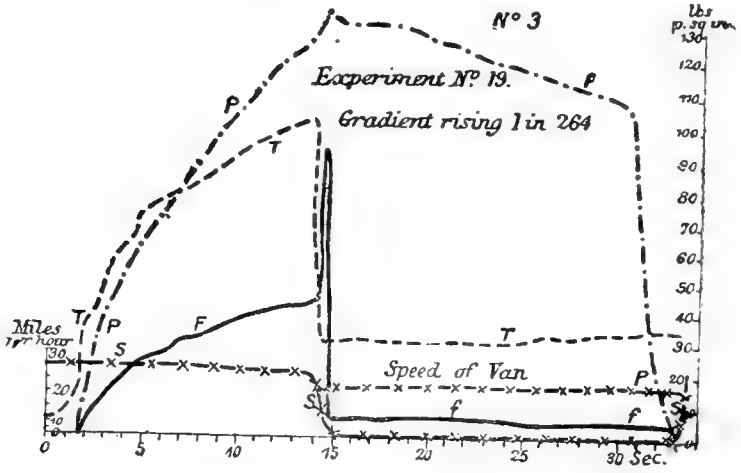
upon the rail. The experiments were made with the object of measuring the force thus brought into action.

The first result of the experiment was to show conclusively that the retarding effect of a wheel sliding upon a rail is much less than when braked with such a force as would just allow it to continue to revolve.

The annexed copies of two sets of diagrams (No. 1 and No. 2) taken during the experiments, show, more clearly than can be explained, the difference in the retarding force, before the wheels begin to slide upon the rails, and after. These



two experiments were made with a single van slipped from the engine, the brakes going on automatically when separation from the engine took place. S is a line showing the speed of the van at each instant, the scale for which is at the left side. P is the pressure against four blocks acting upon one pair of wheels; the vertical height of P by the scale on the right hand, multiplied by 240, gives the total pressure in pounds on the four blocks. F is the line showing the retarding effect of the four blocks upon the one pair of wheels before the wheels began to slide upon the rails, and *f* shows the effect while the wheels were sliding upon the rails. The



vertical height of F or *f*, according to scale B, multiplied by 60, gives the retardation in pounds. It will be seen that the stop was made in half the time with the wheels braked but not skidded of that required when the wheels were skidded.

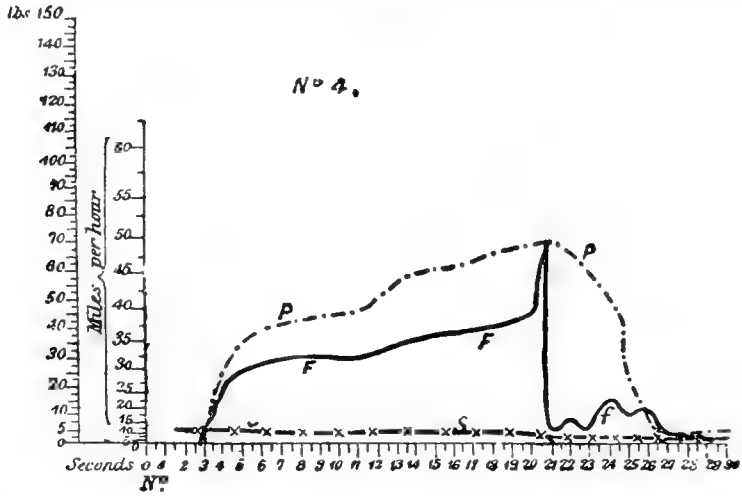
The accompanying diagram 3 shows in another way the comparative retarding effect of the brakes when acting on the revolving wheels, and when applied with sufficient force to skid the wheels.

An experiment was made by keeping the van at a uniform speed on a rising

gradient of 1 in 264—the strain on the draw-bar being also measured during the experiment. In this case the strain on the draw-bar diminished in the same ratio as the friction.

From this it is evident that the retardation which arises when the wheel is sliding on the rail is far less than the retardation produced by the effect of the brake-blocks when applied to the wheels so as to allow the wheels to continue revolving.

In order to understand this it is necessary to consider the general action of railway brakes. When a train is moving at a given velocity the adhesion of the wheels on the rails causes them to revolve; every point on the surface of the tyre moves round at the same rate as that at which the train itself is moving forward; but every such point in relation to the forward movement of the train comes successively to rest at the moment when it comes in contact with the rail. Now when the brake is applied with a slight pressure only, the wheel continues to move round at the same rate as that at which the train is moving, but it moves with more difficulty, and this increased difficulty in moving is shown either by an increase in the tractive force required to keep up the forward motion, or, in cases where the accelerating force is not kept up, by the tendency of the moving mass to come to rest in a shorter time than would otherwise be the case. But if the pressure

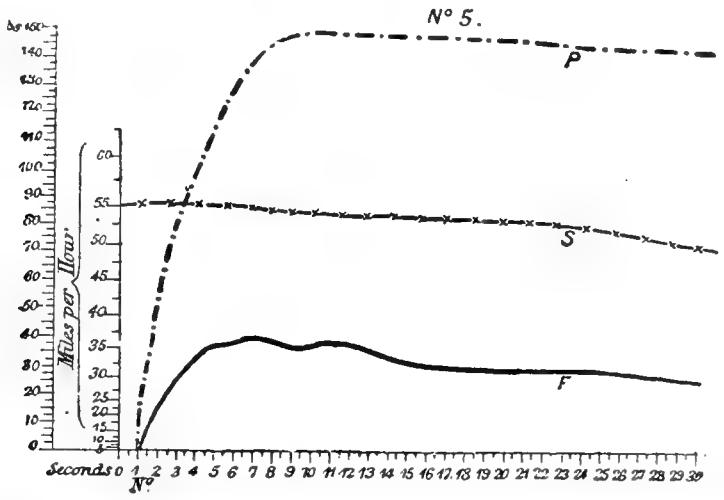


with which the brake is applied be increased, a point is reached when the friction between the brake-block and the wheel first approaches, then equals, and finally exceeds, the adhesion of the wheel on the rail. When this happens, the wheel first begins to revolve more slowly, and then ceases to revolve and slides along the rail, or, as it is usually termed, is skidded. The retardation is then no longer due to the friction between the brake-block and the tyre of the wheel; but the vehicle is transformed for the time from a vehicle on wheels into a sledge, and the retardation is due to the excess of resistance which is produced by making the vehicle slide along the rails over that produced by making the vehicle move forward on wheels revolving freely.

The reason why the retardation caused by the brake-blocks applied to revolving wheels exceeds that caused by the skidded wheels became obvious from the fact next discovered, viz., that the coefficient of friction between the brake-blocks and the wheels varied inversely according to the speed of the train, a higher proportionate percentage of brake-block pressure being required to obtain a given amount of friction at high speeds, and a lower pressure at lower speeds.

This is illustrated by the diagrams 4, 5. In these diagrams P represents pressure, F friction, and S speed, measured on the respective scales at the side, to be corrected by the multiple before mentioned. It will be observed that the ratio of

F to P in diagram 4, with a speed of eleven miles per hour, is much larger than that of F to P in diagram 5, with a speed of fifty-five miles per hour.

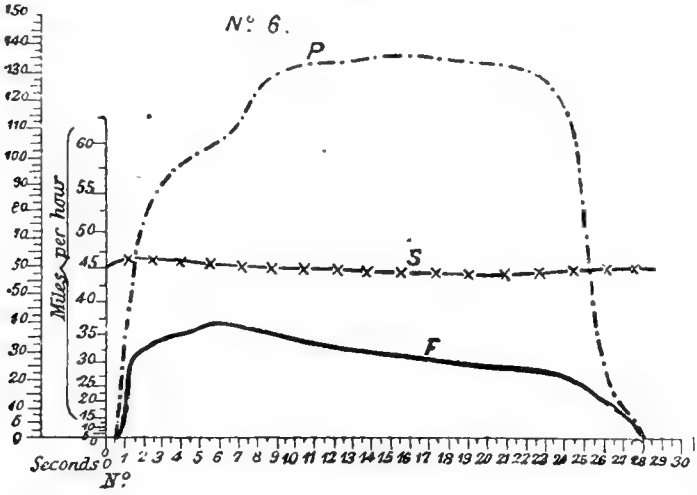


The following table shows the coefficient of friction obtained from these experiments at varying speeds between cast-iron brake-blocks and steel tyres:—

Number of experiments from which the mean is taken	Velocity		Coefficient of friction		
	Miles per hour	Feet per second	Extremes observed		Mean
			Maximum	Minimum	
12	60	88	·123	·058	·074
67	55	81	·136	·060	·111
55	50	73	·153	·050	·116
77	45	66	·179	·083	·127
70	40	59	·194	·088	·140
80	35	51	·197	·087	·142
94	30	44	·196	·098	·164
70	25	$36\frac{1}{2}$	·205	·108	·166
69	20	29	·240	·133	·192
78	15	22	·280	·131	·223
54	10	$14\frac{1}{2}$	·281	·161	·242
28	$7\frac{1}{2}$	11	·325	·123	·244
20	Under 5	Under 7	·340	·156	·273
—	Just moving		—	—	·330
Fleeming Jenkin . .		·0002 to ·0086	·337	·365	·351
Static friction (Rennie)					
180 lbs. per square inch		—	—	—	·300
336 lbs. per square inch		—	—	—	·347

If the position of the brake-blocks were always the same at the same speed, some simple rule might be deduced which would give the pressure required at each speed for obtaining a certain amount of retardation; but when the speed of the van was kept nearly uniform by the effort of the engine, the friction of the blocks decreased; and this occurred, notwithstanding a continued increase of the

brake-block pressure, showing that, through some cause not yet fully determined, the holding power of brake-blocks at all speeds is considerably less after some seconds of application than when first applied. This peculiarity is illustrated by diagram 6, and is also apparent in diagram 5. Hence the question of the proper amount of brake-force needed at each instant, during the time required to stop a



train, is still further complicated by this decrease which occurs in the coefficient of friction after the brakes have been applied, and which results from the time during which they are kept applied, irrespective of any change in speed. This decrease in the coefficient of friction is shown in the following table:—

Coefficient of Friction as affected by Time.

Speed. Miles per hour	Coefficient at commencement of experiment	After 5 seconds	After 10 seconds	After 15 seconds	After 20 seconds
20	·182	·152	·133	·116	·099
27	·171	·130	·119	·081	·072
37	·152	·096	·083	·069	—
47	·132	·080	·070	—	—
60	·072	·063	·058	—	—

Diagram 7 shows the curves of this decrease obtained from a few of the experiments. It would seem as if the coefficient of friction due to each speed becomes nearly uniform after a certain number of seconds have elapsed. The experiments were, however, necessarily limited to something between twenty and thirty seconds each, so that this point has not been fully determined.

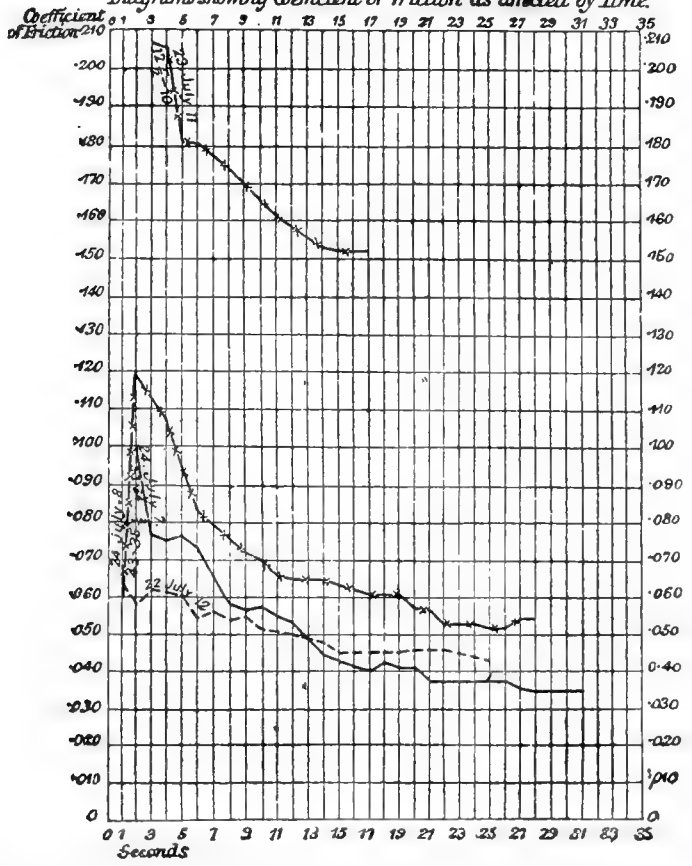
The decrease in the coefficient of friction arising from time sometimes overcomes the increase in the coefficient of friction arising from a decrease in speed; especially when, either from the stop being on a descending gradient or from a small proportion of the train only being fitted with brake power, the train takes considerable time in coming to rest. Therefore, a higher brake pressure is required in such cases than when the stop is made in a short time.

The accompanying diagram (8) shows a uniform force of friction with a practically uniform speed, as obtained by means of an increasing brake-block pressure. The line P shows the pressure, F the friction, and S the speed, which decreased slightly during the experiment, and would have caused an increase in the coefficient of friction had it not been counteracted by the element of time.

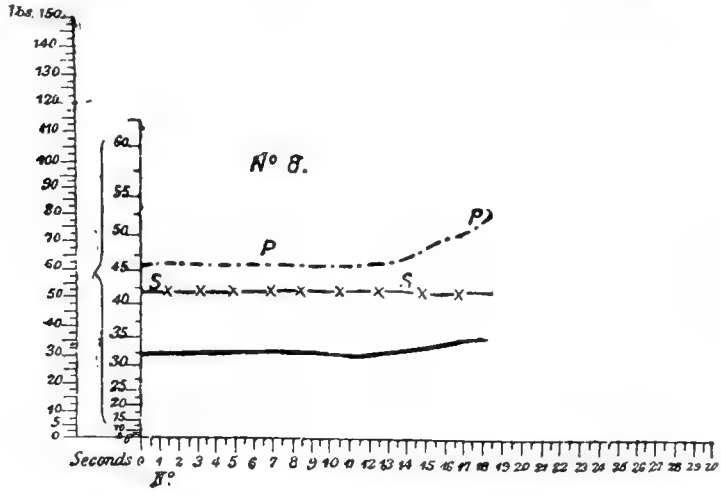
There is nothing unnatural in the fact that friction decreases with speed. Friction is mechanical work; it requires a definite force to move a body which is

N° 7.

Diagrams showing Coefficient of friction as affected by Time.



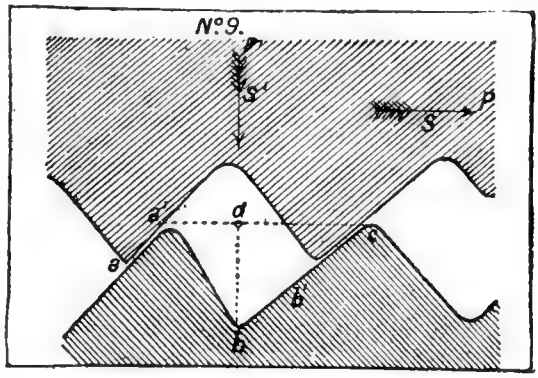
in contact with another, and such movement causes a perceptible wear of the surfaces in contact. The manner in which this work is accomplished can be explained



only by the fact that the surfaces in contact are not perfectly smooth, but irregular,

although this irregularity may not be distinctly visible to the naked eye. These surfaces, if examined under a sufficiently strong microscope, would be found to be somewhat as represented in the accompanying diagram, No. 9.

If the upper body be moved in the direction of the arrow, S, by a force, P, the point, *a*, of the upper surface would mount the incline, formed by the corresponding portion of the lower body, until it reached its summit at *a'*; from this moment it would begin to descend the next incline, from *a'* to *b*; provided the force, P, acting in the direction of the arrow, S, would leave it time to do so. The incline from *b* to *c* would have to be mounted next, causing a certain amount of resistance during the time the body traversed the distance *d c*. But if we increase the speed in the direction of the dart S, so that the body will require less time to traverse *a' d* than to fall through *d b*, in such case *a'* would not arrive at *b*, but at some other point, *b'*, and then only the portion of the incline *b' c* would have to be mounted, presenting a smaller amount of resistance than in the former case. This illustrates what occurs.



The fact that the coefficient of friction diminishes with speed sufficiently explains why a skidded wheel affords less resistance than one which still rotates, because the resistance occasioned by the rotating wheel is only limited by the adhesion of the wheel on the rail, and this, as already shown, is the same as static friction, since the point of the wheel is stationary as regards the forward movement of the train at the moment it touches the rail; whilst when the wheel is skidded and slides, the friction is that due to the speed at which the wheel moves on the rail, and is therefore less than the other.

Some special experiments were made with blocks of small area. The brake-blocks generally used in these experiments were 12 inches long, by 3 inches wide, giving a surface of 36 square inches; the small brake-blocks were made so as to afford a surface of pressure against the wheel of only one-third of this amount, or 12 square inches, thus making the pressure per square inch three times as great as before. The diminution of surface was obtained by casting projections upon the face of the block. The author is not prepared to say that any greater coefficient of friction was obtained by the extra pressure per square inch, although in one of the experiments, at a velocity of sixty miles an hour, the rotation of the wheels was arrested by these blocks, whilst this effect had not been produced at that speed in other experiments. The experiments on this form of block were stopped because the blocks were entirely worn down in the course of about twelve experiments.

Mr. Rennie showed[1] that high pressures per square inch produced a greater coefficient of friction between surfaces either moving very slowly or nearly at rest; but it must be borne in mind that the author's experiments were made with high velocities, whereby a serious element of disturbance is introduced, viz., the grinding away of the surface; and it is, therefore, probable that the increase in the coefficient of friction due to increased pressure, may have been neutralised by the lubricating effect of the fine particles ground off the surfaces.

While no certain opinion can be expressed as to the relation which the coefficient of friction bears to pressure, so far as these experiments are concerned, it is quite clear that in proportion as the pressure is increased or diminished, so will the actual friction obtained be increased or diminished. When the friction which exists between the brake-blocks and the wheel reaches a certain point, the wheel ceases to rotate, and becomes fixed. This point is reached when the frictional

[1] *Phil. Trans.* for 1829, p. 159.

resistance of the blocks exceeds the adhesion between the wheel and the rail if the speed is kept up; or, if the speed is slackening, when it exceeds the adhesion between the wheel and the rail, plus the effort required to retard the rotation of the wheel equally with the retardation of the train; and the excess of resistance then acts as an unbalanced force, tending to destroy the momentum of the wheel.

Usually there are in a train a certain number of vehicles braked and a certain number unbraked. If the brakes acted on all the wheels, then the rotating momentum of the wheels does not add to the distance in stopping a train, because that momentum can be acted upon by the brakes directly, without in any way affecting the adhesion of the wheels to the rails. It simply requires an additional amount of brake-block pressure.

With the unbraked portion of a train the rotating momentum of the wheels is an addition to the momentum due to the weight of the train (including therein the actual weight of the wheels), which cannot be utilised for retardation; and it is therefore important that there should be brakes on every wheel of a train.

As it is the adhesion which governs the retardation which the brake-blocks can exert upon wheels, it is manifest that the pressure brought to act on the brake-blocks should never give an amount of friction which exceeds the adhesion. At a high speed, however, the pressure required to produce a degree of friction equal to the adhesion is much greater than what is required at a low speed.

The following table gives approximately the proportion which the pressure to be applied to the brake-blocks should bear to the weight upon the braked wheels, with coefficients of adhesion between wheel and rail, varying from ·30 to ·15 of the weight on the wheels:

Ratio of Brake-Block Pressure to Weight on Wheels.

Speed		Ratio of pressure on brake-blocks to weight on braked wheels			
Feet per second	Miles per hour	Coefficient of adhesion 0·30	Coefficient of adhesion 0·25	Coefficient of adhesion 0·20	Coefficient of adhesion 0·15
11	7½	1·20	1·04	0·83	0·60
22	15	1·41	1·18	0·94	0·70
29	20	1·64	1·37	1·09	0·82
44	30	1·83	1·53	1·22	0·92
59	40	2·07	1·73	1·38	1·04
73	50	2·48	2·07	1·65	1·24
88	60	4·14	3·47	2·77	2·08

It will be seen that, when the adhesion equals ·30 of the weight, a pressure equal to 1·2 of the weight would skid the wheel at 7½ miles per hour, whilst a pressure equal to 4·14 times the weight would be required to do so at 60 miles per hour.

On the other hand, if the adhesion is only ·15, the pressure required to skid the wheel would be only ·60 of the weight at 7½ miles per hour, and 2·08 of the weight at 60 miles per hour.

Thus the efficiency of a brake depends upon the pressure being proportioned to the speed and to the adhesion. If the adhesion were always uniform, the rule would be very simple; but this is not the case.

The adhesion of the wheels to the rails varied according to the materials, that is, whether the train was travelling upon iron or steel rails; and according to the state of the rail, whether dry, wet, or sanded.

On dry rails it was found that the coefficient of adhesion of the wheels was generally over ·20. In some cases it rose to ·25, or even higher. On wet or greasy rails, without sand, it fell as low as ·15 in one experiment, but averaged about ·18. With the use of sand on wet rails it was above ·20 at all times; and when the sand was applied at the moment of starting, so that the wind of the rotating wheels did not blow it away, it rose up to ·35, and even above ·40. Con-

sequently, the retarding effect of the brakes would be greatly increased, were means devised for placing sand under every wheel to which a brake is applied, during the progress of a stop.

The effect in stopping a train is greatest when the friction between the brake-blocks and the wheels amounts to a quantity just short of the resistance caused by the adhesion, because as soon as the brake-block friction exceeds the adhesion, the wheel becomes fixed and begins to slide. In order, however, to secure the best results in stopping, it is obviously necessary that the brake-block pressure should be regulated to give a friction about equal to the adhesion of the wheels at every stage during the progress of a stop.

There is no reason why, in the progress of mechanical science, these conditions should not be regulated by a self-acting arrangement.

As the adhesion varies it is necessary to consider what amount of adhesion for purposes of retardation can be safely calculated upon.

The following table shows the distances required to stop a train on a level line from a speed of fifty miles per hour, with a retarding force of from 5 to 30 per cent. of the total weight of the train:—

Percentage of retardation	Yards run at fifty miles per hour	Percentage of retardation	Yards run at fifty miles per hour
5	$555\frac{2}{3}$	18	$154\frac{1}{3}$
10	$277\frac{2}{3}$	20	139
12	$231\frac{1}{3}$	25	111
15	185	30	$92\frac{2}{3}$

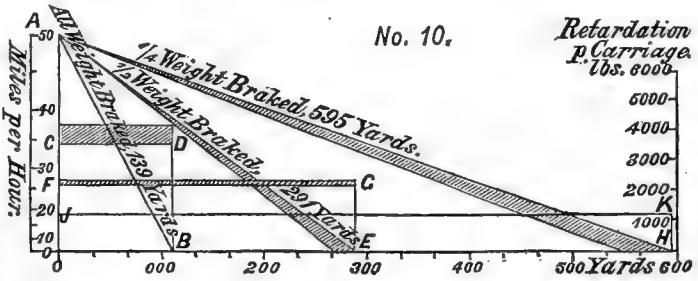
If the brakes act upon each wheel, then a retardation of 10 per cent. of the load carried by each wheel—counting the rotating momentum as part of the weight—will stop a train in $277\frac{2}{3}$ yards.

If the brakes act upon only half of the weight of a train, a retardation of 20 per cent. would have to be exerted upon the braked half to produce the same result. As pointed out, 20 per cent. adhesion is rather above the average obtainable, while 25 per cent. is the highest result obtained under the most favourable circumstances at any considerable speed, or except when sand was applied to wheels moving slowly.

The above table should be carefully noted, for it will be seen that, even if brakes act upon all wheels, 25 per cent. retardation will only give twenty-eight yards better result than 20 per cent., or if half of the train only be braked, it will give fifty-nine yards advantage.

A consideration of this feature of the brake problem points out (1) that the advantage to be gained by trying to obtain above 20 per cent. retardation on each wheel is greatly overbalanced by the risk of 'skidding;' and (2) that it is far easier and safer to make a stop in 250 yards from fifty miles per hour with the whole train braked, than with brakes upon only half of the train.

The following diagram, No. 10, shows the advantage of applying brakes to every



wheel of a train. The line AB shows the stop which a train would make from fifty miles an hour with the retardation of 20 shown by the horizontal line CD if

applied to every wheel of the train. The shaded area below CD shows the extra retardation consumed to overcome the momentum of the braked wheels.

The diagonal line AE shows the stop with the same retardation applied to half the wheels and half the weight of the train, as indicated by the line FG. The shaded portion below the line FG shows the extra retardation caused in overcoming the momentum of the braked wheels, and the shade below AE shows the extra distance run by the train owing to the momentum of the unbraked wheels.

The diagonal AH shows the stop with the same retardation of ·20 applied to $\frac{1}{4}$-wheels and $\frac{1}{4}$-weight of train as indicated by JK. The thickness of line JK and diagonal area shaded below AH show respectively the extra retardation consumed in overcoming the momentum of the braked wheels, and the extra distance run by the train in consequence of the momentum of the unbraked wheels.

From the experiments it was found that the best results were obtained in cases where the pressure applied at first was from about $1\frac{2}{3}$ to twice the weight on the wheels, and where the reduction of the pressure was effected with sufficient rapidity towards the end of the stop to prevent the friction increasing at a sufficient rate to skid the wheels.

The necessity for the instantaneous application of the maximum brake-block pressure throughout the train is evident from the fact that, at a speed which is frequently obtained, namely, sixty miles per hour, a train passes over 88 feet each second; therefore the loss of two or three seconds in applying the brakes means often the difference between safety and danger, and the rapidity of a stop largely depends upon the rapidity with which all the brake-blocks can be brought to act against the wheels of a train.

This points to the advantage of being able to move the brake-blocks with great rapidity from their position of inaction to that of contact with the wheels; because it is essential to provide that the brake-blocks, when out of use, shall be removed to a distance from the wheels sufficient to prevent the possibility of their dragging against the wheels, and thus retard the progress of the train. The question of the rapidity with which brakes can be applied in practice is thus one of much importance.

Some experiments were made in October 1878, upon the North Eastern Railway, on a train fitted with the vacuum brake, and one fitted with the Westinghouse brake, to ascertain the time which was required after moving the brake-handle to set the brakes with various degrees of force in different parts of the train. The following table shows the result arrived at:—

Place of experimental van from engine	Vacuum brake				Westinghouse automatic brake			
	Commencement of movement of blocks	Half on	Three-quarters on	Full on	Commencement of movement of blocks	Half on	Three-quarters on	Full on
	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.
1st vehicle	$\frac{1}{2}$	3	7	11	$\frac{1}{4}$	$\frac{5}{8}$	$\frac{3}{4}$	$1\frac{1}{2}$
7th „	2	$6\frac{1}{2}$	$8\frac{1}{2}$	14	1	$1\frac{3}{4}$	2	$2\frac{1}{2}$
13th „	$3\frac{1}{2}$	$7\frac{1}{2}$	$9\frac{1}{2}$	14	$1\frac{3}{4}$	$2\frac{3}{4}$	$3\frac{1}{8}$	$3\frac{1}{2}$
21st „	$5\frac{1}{2}$	17	30	—	3	$4\frac{1}{2}$	5	$5\frac{1}{2}$

A long interval of time between brakes coming on at the front and rear of a train may become a source of danger; and improvements have been introduced in both the vacuum and Westinghouse apparatus since that date to reduce the interval as shown by the experiments.

In the Westinghouse brake a simplified triple valve has been adopted, the friction has been reduced by the use of an enlarged pipe and by the removal of bends in the connections between the carriages; by these alterations the interval of time required to put on the brakes, as shown in the above table, has since been reduced by nearly one-half, and an experiment recently made on the application of the brake in rear of a train of twenty-four vehicles on the Western Railway of

France showed that the pressure commenced to be brought on in one second at the farthest carriage, and was fully one in two and a half seconds from the time of first moving the brake lever.

The importance of simultaneous action of the brakes in every part of a train arises from the fact that the train is not a rigid mass, but is made up of separate vehicles connected by means of spring draw-bars and buffers. The length of the train can thus be modified to a certain extent by the degree of compression of these springs. In a recent experiment on the North-Eastern Railway the train consisted of twenty-four carriages, and the whole extent to which the buffers could be compressed amounted to 35 feet. A train travelling at sixty miles an hour moves at 88 feet in a second. If the brakes act on the front part of the train before they affect the hind part the speed of the front carriages may be diminished by 10 to 15 feet in a second, whilst the hind part moves on with undiminished speed; thus the hind part may press against the front part with a force of from 10 to 15 foot-tons for every ton weight of the hind vehicles. The buffer springs would be compressed by this force and remain so till the brakes acted equally on all the wheels, when a reaction of the buffer springs would take place; this reaction creates the violent jerks often felt with continuous brakes, and occasionally results in fractures of couplings and draw-bars. In a perfect brake the application would be instantaneous, and simultaneous on all the wheels of a train.

It is beyond the scope of this paper to enter fully into the merits of different kinds of brakes, but it may be convenient to sum up what seem to be the requirements of a perfect brake.

1. It should be fitted to act upon each wheel of the engine, tender, and every other vehicle in a train of any length. The brake-blocks, when out of action, must be kept a certain distance away from the wheels, in order to prevent any liability to drag against the wheels; and this distance, after being once adjusted, gradually increases by the wear of the blocks, and often exceeds three-quarters of an inch; while the springing of the brake-gear under great strain also adds to the extent of movement required in the brake force before the blocks are fully applied. Hence the brake-gear should be so adjusted as to be capable of moving the brake-blocks instantaneously through a space of one inch.

2. However brought into action, it should be capable of exerting upon the blocks of each pair of wheels, within two seconds, a force of twice, or at the very least one-and-three-quarter times, the load on those wheels.

3. The brake-block pressure acting on each wheel should be regulated so that the friction between the brake-block and the wheel may always be limited so as not to exceed the adhesion between the wheel and the rail; by which means it will produce the maximum effect at each moment of its application.

4. The brake-block pressure should be capable of being applied by engine-driver or by guards.

5. The engine, tender, and vehicles should each carry its own store of brake-power, which should be independent of the brake-power on any other vehicle.

6. The brake-block pressure should be automatically applied to every vehicle by the separation of the train into two or more parts, and it should also be applied by the act of the wheels of any carriage leaving the rails.

7. The brake-block pressure should be automatically applied by such failure of the connections or appliances as would render it afterwards incapable of application until the failure had been remedied.

8. The brake-block pressure should be capable of application with any degree of force up to the maximum, and it should be capable of continued action on inclines, or of repeated applications at short intervals at junctions and stations.

In addition to these requirements, the questions of cost, durability, convenience in operation, and other essential points, will of course come under consideration.

The experiments which have been here described were made on trains travelling under conditions which were necessarily continually varying, both in respect of the condition of the rails and other matters; and they therefore contained many elements beyond the reach of calculation. It is hoped that some opportunity may arise, ere long, for resuming experiments on friction at high velocities under

conditions from which these elements of disturbance may be eliminated. Meanwhile it is evident that a continuous brake, capable of being applied simultaneously to every wheel of a train under the conditions which have been enumerated in this memorandum, is a much more practical and scientific method of bringing a train to rest than the old plan of concentrating the brake-power in two or three heavy brake vans placed in different parts of the train, and leaving the rest of the wheels without brakes.

The advantage which thus evidently ensues from utilising the adhesion of every wheel of a train for the purpose of stopping a train suggests the further consideration as to whether it would not be a more scientific arrangement, as well as more economical in regard to the permanent way of railways, to utilise the adhesion of every wheel of a train for causing the train to move forward, instead of depending for the moving force upon the adhesion of one heavy vehicle alone, viz., the locomotive. Experiments connected with the action of brakes on railway trains require very delicate apparatus; the credit of the design of the apparatus used in these experiments belongs to Mr. Westinghouse. The efficiency of the arrangements for making the experiments is due to the London, Brighton, and South Coast Railway Company, as represented by Mr. Knight, their general manager, who afforded every facility for the use of the line, and by Mr. Stroudley, the locomotive engineer of the Company.

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6. *Cowper's Writing Telegraph.* *By* E. A. Cowper, *C.E.*

The inventor described the details of the construction of his writing telegraph, and the mode in which a pen at a distant station was made to write freely, as the operator at the sending station wrote with a pencil at the sending instrument. He explained the necessity that existed for causing the two currents of electricity that conveyed the power to the distant station to increase or decrease steadily and gradually, without any sudden large increase or decrease of resistance being opposed to such currents; the construction of the necessary resistances being practically that of one very long thin German silver wire, having 32 thin metal plates soldered to it, at the proper intervals (varying greatly), such plates being all brought very close together, with insulating sheets of paraffined paper between them, so that a contact rod in connection with a battery, with a small knob or projection on it, could slide over the tops of the plates, and make contact with each one in succession; making contact with one before it left another, so that the small resistance due to the length of wire between two plates was all that was added each time that the projection passed from one plate to another. Then two such contact rods, jointed to the pencil of the operator, and placed at right angles to one another, worked over the tops of two separate sets of contact plates, each set affecting one line wire, so as to give (so to speak) latitude and longitude of the pencil of the operator at all times.

The quick action or perfect response of the needles at the receiving instrument, which directly controlled the writing pen, was obtained by using exceedingly thin soft iron plates, both for the needles and for the magnets which affect the needles, so as on the one hand to have the least possible amount of momentum and *vis inertia* in the needles, and the least possible residuary magnetism in the magnets. The needles were slightly curved in their section to stiffen them, their thickness being only $\frac{1}{110}$ inch, and were mounted on polished hard steel bearings, in the manner adopted for the balance wheels of watches when jewelled, and were thus exceedingly free and lively, as a very small amount of friction or weight in this part of the instrument would be fatal to good writing. The power of the needles was insured by fixed flat coils that surrounded them, brought into action by a local battery, whilst the two line wires were coiled around the fixed magnets that affected the needles, and attracted them more or less, as the strength of the currents varied. Then the needles being at right angles to each other pulled the pen in the two directions, vertically and horizontally, and also pulled against two

light springs, so that the pen took exactly the varying positions due to the varying strength of the currents, which again depended upon the position of the pencil of the operator.

The paper on which the operator wrote, and the paper on which the pen wrote at the opposite end of the line, both moved along by clockwork, so as to write a long continuous message or telegram.

TUESDAY, AUGUST 26, 1879.

The following Papers were read:—

1. *On the Proposed Canal Across the Isthmus of Panama.* *By* Captain Bedford Pim, *R.N., M.P.*

The author said the whole world agreed that the accomplishment of inter-oceanic canalisation of the Isthmus of Central America was only a question of time. No one disputes the possibility of making such a canal, and it was generally acknowledged that it might be made a paying concern. The congress on inter-oceanic canalisation did not deal practically with the subject, and the enthusiasm, which was so important an element in the greatness of the French people, blinded those who took part in the congress to the magnitude and the difficulties of the task, and to the fact that the work already done by M. Lesseps bore about the same relation to the proposed Panama Canal that a small tunnel on the northern of France would to that of the Mont Cenis. The physical geography of the Bay of Panama was never taken into consideration, and he was bound to say that the vote in favour of a canal parallel to the Panama Railway was due rather to a personal feeling than to any capability possessed by the route selected. In fact it was rumoured that the process known by our cousins across the Atlantic as 'lobbying' was by no means neglected on this occasion; it was not therefore surprising that the American representatives expressed their feelings in terms of the strongest, and, not content with that, made anything but a favourable report to their own Government. It was not alone the physical difficulty of the undertaking, or even its cost, to which attention should be given. The choice of a route depended upon far more important considerations than those—the terminal ports or harbours for instance. A still more important feature was the physical geography of the sea in the neighbourhood of the ports, for if sailing ships would be able freely to enter and depart, the success of the undertaking was secured. At least half of England's 21,000 sailing ships would use the canal, but if nature placed an irresistible barrier to the approach of those ships a deep shadow would be cast upon the future outlook of the undertaking. Commodore Maury had said 'that if nature, by one of her convulsions, should rend the Continent of America in twain, and make a channel across the Isthmus of Panama or Darien as deep, as wide, and as free as the Straits of Dover, it would never become a commercial thoroughfare for sailing vessels,' and he endorsed that opinion, for of all parts of the world the calms in the Bay of Panama were the most vexatious and enduring. It therefore became the duty of a Central American canal projector to avoid that locality, and, relying upon Commodore Maury, the route from the Atlantic by way of the magnificent Nicaragua lakes to the harbour of Realejo seemed that which was adapted for the required purpose, for it would be quite impossible to exaggerate the money value of having a fair start and approach by means of the little monsoons which blow on that coast. The great difficulty to be overcome in the construction of a canal across Nicaragua was the making and maintaining the harbour of Greytown on its Atlantic terminus, as a strong norther was

sufficient to close it, while a high river would re-open an entrance. He thought the cost of the enterprise would paralyse the enterprise, and he would suggest an alternative route parallel to the river San Juan, with a canal of very different dimensions, and cost to, that at present contemplated. Starting from Monkey Point, now called Pim's Bay, forty miles north of Greytown, he would cut a canal from the inner part of that bay down to the Rama river, a distance of some nine miles. The Rama river itself carried deep water some twenty miles into the interior, and the remaining seventy miles to the lake of Nicaragua would traverse land offering no particular difficulty. From San Miguelito on Lake Nicaragua by way of Tipitapa to the northern shores of Lake Nicaragua there was nothing which an engineer would consider a difficulty, and the remainder of the canal to Port Realego could scarcely be said to afford any field for engineering skill. In that scheme a deep water canal was not even contemplated. A depth of eight feet would be amply sufficient, the vessels being transported on pontoons, such as had been successfully used in the Victoria Dock for some years; whilst the canal could always be deepened, if desirable, out of profits. Such a plan would considerably reduce the cost, while other advantages would be gained, such as cleaning the ship's bottom while on the pontoon, which would effect a saving to owners almost if not quite sufficient to pay the canal dues. The canal would not cost more than ten millions. If England and America would join hands and each guarantee $1\frac{1}{2}$ per cent. on that amount, there would be a joint guarantee of 3 per cent., an inducement sufficient for English investors alone to take up the sum in less than a week. What was $1\frac{1}{2}$ per cent. on ten millions? 150,000*l.* a year; a sum annually wasted on any vote of the navy estimates exceeding one million. And what did we get for our money? A consolidation of the friendly feeling between this country and the United States far more lasting and binding than could be effected by any treaty between the two nations merely guaranteeing the neutrality of the route. The representative of the American Government at the Paris congress left no room for doubt as to the line of canal preferred by his Government, and clearly and unmistakably pointed to Nicaragua as the best. He (Captain Pim) trusted the Government of this country would not for the sake of saving the contribution of 150,000*l.* for a few years find themselves ultimately compelled to purchase an interest in the new highway at any price which might then be demanded. He most earnestly hoped that the day would not be far distant when we should see the completion of this great work of inter-oceanic canalisation across Central America. He believed such an undertaking would give a beneficial stimulus to the commerce of the United Kingdom, nay of the whole world, and consequently could not fail to be a great and common boon to mankind.

2. *Cowper's Hot Blast Stoves.* *By* E. A. Cowper, *C.E.*

Mr. Cowper described the improvements introduced in recent years for heating the blast for blowing blast furnaces by a more perfect application of the regenerative system, by which the waste gases from the top of the blast furnace, when in a state of perfect combustion in the hot blast stove (during the time of heating it) were distributed in a more perfect manner than heretofore, so that the hot products of combustion were caused to heat the whole area of the regenerator in an equal manner, the result being a large increase in the power of the stove, as well as a saving of time in the heating. By the improved combustion of the gases, a higher degree of temperature was produced in practice and a higher temperature of blast was realised, whilst the products of combustion finally left the stove at a lower temperature, so that economy of gas followed as a consequence. Upwards of 110 stoves were now at work in England, France, Switzerland, and America, giving perfect satisfaction and realising an economy in fuel of 20 to 30 per cent., whilst 20 per cent. more iron was made from the same plant, of furnace, blowing engine, and boilers.

3. *On the details of an Experiment made to Ascertain the Causes of the difference between the Quantity of Heat in Fuel, and the Quantity which is Utilised in the Work done by a Steam Engine.* *By* EMERSON BAINBRIDGE, *Assoc. M.C.E.*

The engines of H.M.S. *Briton* have been represented as types of the most economically worked steam engines of modern times, and the percentage of heat used in doing work in the case of these engines, as recorded by Mr. Bramwell, was 11·1 per cent.; that is, the indicated power of the engines showed a utilisation of 11·1 per cent. of the units of heat contained in the fuel used, this being equivalent to a consumption of 1·8 lbs. of coal per horse-power per hour. If this figure represent the highest result obtained, it will be readily understood how much lower the actual average of utilised power in steam engines constructed and worked in the usual way will be. The difference between 11 per cent. as the proportion of heat utilised which has been proved to be *possible*, and 5 per cent. which may be, at the most, the *average actual* percentage utilised in the working of steam engines, suggests a wide field for inquiry and improvement. But a more difficult subject for examination is presented by the difference between such 11 per cent. and the actual heat-power contained by fuel, which is, of course, represented by the figure 100, and whilst a large proportion of the great loss represented by the non-utilisation of such a difference can never be overcome, the importance of the inquiry is evidenced by the fact that every *one per cent.* gained, means, over the consumption of this country alone, a saving of several millions of tons of coal per annum.

The result above referred to shows the percentage utilised as proved by the indicating of the cylinders of engines, but does not give the percentage represented by the *work done*. In the case which the writer now records he has endeavoured to work out the details of the distribution of the heat of fuel in various stages, commencing at its combustion under a boiler, and ending at the actual useful work done by the engine, worked out to units of heat.

Of the total annual output of coal in this country the quantity actually used in the production of steam amounts to about 50 millions of tons, or about 37 per cent. of the whole output, and it is with this appropriation of fuel this paper has specially to deal.

The experiment above referred to was made with the Winding engine and boilers of a small Colliery, such plant being nearly thirty years old, and situated about two miles from Sheffield. This pit is 458 feet deep, and the Coals &c. are raised by a direct-acting Winding engine, to which steam is supplied from two boilers.

During the time of observations, which extended from July 28 to August 2, in all 184·5 hours, the following observations were carefully taken:—

1. The quality of coal used was the same throughout, and was carefully weighed.
2. The amount of ash and clinker produced was observed.
3. The quantity of water passed into the boiler was ascertained by a tested water-meter.
4. The total number of the revolutions of the engine during the whole period was taken by a counter, the work done by the engine being in each case recorded.
5. Observations were taken of the temperature of the feed water.
6. Observations were taken of the temperature of the outside air.
7. Observations were taken of the temperature of the gases escaping to the chimney.
8. Observations were taken of the temperature of the outside of the boiler covering.
9. Observations were also taken of the temperature of the covering on the outside of the cylinders and steam pipes.

10. Observations were taken of the quantity of air passing into the fireplaces, which was recorded by an anemometer.

11. A record was taken as to the actual weight of Coal, dirt, men and water lifted during the continuation of the experiments.

12. Diagrams (continuous and single) of the cylinders were taken to show the power expended by the engine in raising Coal and water, and when working with empty tubs.

The chief data as to the experiments are shown in the accompanying statement.

Abstract of Experiments.

Duration of experiments	184·5 hrs.
Coal used	29,344 lbs.
Ash and clinker produced	1,737 „
Water used	76,080 „
„ „ per lb. of coal	2·59
Coal drawn	2,251,072 lbs.
Dirt, water, and men	2,668,995 „
Slack lifted by hoist	805, 728 „
Total number of draws	3,128 „
Average temperature of feed water	180° „
„ „ at damper	800° „

Although the experiments extended in all 184·5 hours, the time occupied by the engine in actual work did not exceed nine hours per day.

The most interesting results of the experiments may be briefly enumerated as follows:—

1. Only 20 per cent. of the fuel used was utilised in the evaporation of water, and no less than 37 per cent. of the heat in such fuel is not accounted for.

2. Only 3 per cent. of the heat expended in evaporating water is utilised in actual useful work done, and thus of the 15 per cent. which was available for work, $\frac{1}{5}$th (3 per cent.) was actually utilised in the cylinder of the engine.

3. Instead of 11·1 per cent. of heat employed being utilised, as found by indications from an engine of the best type, the utilised heat in the case referred to only amounts to ·69 per cent., or $\frac{1}{17}$th of the result obtained in a first-class engine.

4. The fact that at least 41 per cent. of the total heat is found to have gone up the chimney, when if the coal had been properly consumed, probably not more than 20 per cent. would have been lost in this direction, illustrates the manner in which a great loss may take place when the ingress of air and the mode of fixing the boiler are not properly looked to.

5. The power exerted in moving the dead useless load upon the engine represents 40 per cent. of the total power, as shown by the indicator diagrams.

It is to be feared that the results of the working of the engine and boilers in question are typical of the conditions under which a large number of engines in this country are worked; and although the remarkable waste shown by the series of experiments recorded cannot but suggest the idea of badly arranged plant, the author ventures to submit that the tests are of value in pointing out the importance of such tests being made more frequently, and the extra worth they have when they extend over so long a period (including working and idle time) as 184·5 hours. Had an experiment been made only for a few hours, there is no doubt that a much better result would have been obtained, and this has been proved by the author in this case. In making experiments of this description, the very best form of instruments is required; and if such instruments were in the hands of a careful observer for carrying out a series of tests on a more complete scale than the anthor has been able to arrange, he would not fail to render good service to engineering knowledge.

The author, however, thinks it right to add that in another arrangement of plant at the Nunnery Colliery, which is to be visited by the members on the 29th instant, very different results from those recorded have been arrived at in tests made with well-arranged boilers, and he ventures, by way of comparison, to refer to these tests.

The distribution of the units of heat have, in this case, been carefully worked out with the following results:—

Test made with double tubular boiler, with cross tubes, Hyde's & Bennett's setting	Units of heat	Per cent.
Units of heat utilised in evaporating	31,198,374	89·28
„ „ lost in chimney	2,655,528	7·60
„ „ by radiation	66,408	·20
„ „ by contact with cold air	60,054	·17
„ „ in soot	50,012	·14
„ „ in clinker and ashes	703,620	2·01
„ „ unaccounted for	210,004	·60
Total units of heat in the coal . .	34,944,000	100·00

The water evaporated per lb. of coal in this test was 11·45 lbs., or 12·15 lbs. from a temperature of 212°.

As an example of the comparison which exists between the mode of setting boilers just referred to, and the old setting of the cylindrical boilers with which the first test referred to was made, it may be stated that with the mode of setting adopted for the double tubular boiler no less than 90 per cent. of the total outside area of the boiler is exposed *to the gases from the fires.* In the case of the cylindrical boiler, the gases impinged *on only* 32 *per cent.* of the total outside area, such comparison being in the ratio of 3 : 1.

The author ventures to enumerate below some of the chief improvements which might be made in the construction, arranging, and working of plant of the class described in this paper:—

1. The fixing of boilers of an improved description with a minimum thickness of plates and a maximum area of heating surface, the latter and the mode of carrying the gases being so arranged as to absorb as much as possible of the heat passing from the fire.
2. Special attention should be paid to the manner in which air is admitted to the fire and to the working of the damper.
3. The air admitted at the firegrate should be so intermingled with the gases from the fire as to enable a minimum quantity of air to be used, care being taken to prevent carbonic oxide passing off unconsumed.
4. The application of such form of firegrates, and such mode of firing as will enable the cheapest quality of fuel to be used.
5. The complete covering of all exposed hot surfaces of the boiler, steam pipes, &c.
6. Where water is scarce, the application of the best form of water-heater.
7. Where water is plentiful, the adoption of an approved form of condenser.
8. Steam jacketing of the cylinder, and careful attention to mechanical accuracy in the construction of the engine and of all the moving parts.
9. The application of the principles of variable expansion when the work done by the engine varies. At the Blackwell Colliery in Derbyshire, one of the winding engines is fitted up with Guinotte's automatic variable expansion gear, and experiments made with and without the gear at work showed the consumption of fuel to be in proportion of 77·5 : 100 in favour of the expansion gear.
10. In the case of winding engines, the adoption of drums of varying diameters so as to reduce the power which has to be expended during the first few strokes in winding, the load upon the engine thus being equalised.
11. As a general principle the use of steam at a high temperature in order to have the greatest possible difference in temperature between the steam when it reaches the cylinder, and when it has done its work.

In the application of such improvements to ordinary steam engines the saving

in *working cost* must of course be *first* considered, and in the adoption of all such means of promoting economy as have been referred to it may be confidently asserted that the saving in working cost which will be effected by the economy of fuel resulting from the adoption of such appliances as have been mentioned, will as a rule wipe off the extra *first cost* incurred by such appliances in a very short period, since the saving effected will probably vary from 50 to 150 per cent. per annum on the first cost.

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4. *On the Law of the power required for different speeds of the same steam vessel, illustrated, within the limits of experience, by a linear scale of their relation.* *By* ROBERT MANSEL.

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[*An asterisk* (*) *signifies that no abstract of the communication is given.*]

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CONTENTS:—Prof. Daubeny, on the Present State of our Knowledge with respect to Mineral and Thermal Waters;—Major E. Sabine, on the Direction and Intensity of the Terrestrial Magnetic Force in Scotland;—J. Richardson, on North American Zoology;—Rev. J. Challis, on the Mathematical Theory of Fluids;—J. T. Mackay, a Comparative View of the more remarkable Plants which characterize the neighbourhood of Dublin and Edinburgh, and the South-west of Scotland, &c.;—J. T. Mackay, Comparative Geographical Notices of the more remarkable Plants which characterize Scotland and Ireland;—Report of the London Sub-Committee of the Medical Section on the Motions and Sounds of the Heart;—Second Report of the Dublin Sub-Committee on the Motions and Sounds of the Heart;—Report of the Dublin Committee on the Pathology of the Brain and Nervous System;—J. W. Lubbock, Account of the Recent Discussions of Observations of the Tides;—Rev. B. Powell, on determining the Refractive Indices for the Standard Rays of the Solar Spectrum in various media;—Dr. Hodgkin, on the Communication between the Arteries and Absorbents;—Prof. Phillips, Report of Experiments on Subterranean Temperature;—Prof. Hamilton, on the Validity of a Method recently proposed by G. B. Jerrard, for Transforming and Resolving Equations of Elevated Degrees.

Together with the Transactions of the Sections, Prof. Daubeny's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SEVENTH MEETING, at Liverpool, 1837, *Published at* 16*s.* 6*d.*

CONTENTS:—Major E. Sabine, on the Variations of the Magnetic Intensity observed at different points of the Earth's Surface;—Rev. W. Taylor, on the various modes of Printing for the Use of the Blind;—J. W. Lubbock, on the Discussions of Observations of the Tides;—Prof. T. Thompson, on the Difference between the Composition of Cast Iron produced by the Cold and Hot Blast;—Rev. T. R. Robinson, on the Determination of the Constant of Nutation by the Greenwich Observations;—R. W. Fox, Experiments on the Electricity of Metallic Veins, and the Temperature of Mines;—Provisional Report of the Committee of the Medical Section of the British Association, appointed to investigate the Composition of Secretions, and the Organs producing them;—Dr. G. O. Rees, Report from the Committee for inquiring into the Analysis of the Glands, &c., of the Human Body;—Second Report of the London Sub-Committee of the British Association Medical Section, on the Motions and Sounds of the Heart;—Prof. Johnston, on the Present State of our Knowledge in regard to Dimorphous Bodies;—Lieut.-Col. Sykes, on the Statistics of the four Collectorates of Dukhun, under the British Government;—E. Hodgkinson, on the relative

Strength and other Mechanical Properties of Iron obtained from the Hot and Cold Blast;—W. Fairbairn, on the Strength and other Properties of Iron obtained from the Hot and Cold Blast;—Sir J. Robinson and J. S. Russell, Report of the Committee on Waves;—Note by Major Sabine, being an Appendix to his Report on the Variations of the Magnetic Intensity observed at different Points of the Earth's Surface;—J. Yates, on the Growth of Plants under Glass, and without any free communication with the outward Air, on the Plan of Mr. N. J. Ward, of London.

Together with the Transactions of the Sections, Prof. Traill's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE EIGHTH MEETING, at Newcastle, 1838, *Published at* 15*s.*

CONTENTS:—Rev. W. Whewell, Account of a Level Line, measured from the Bristol Channel to the English Channel, by Mr. Bunt;—Report on the Discussions of Tides, prepared under the direction of the Rev. W. Whewell;—W. S. Harris, Account of the Progress and State of the Meteorological Observations at Plymouth;—Major E. Sabine, on the Magnetic Isoclinal and Isodynamic Lines in the British Islands;—Dr. Lardner, on the Determination of the Mean Numerical Values of Railway Constants;—R. Mallet, First Report upon Experiments upon the Action of Sea and River Water upon Cast and Wrought Iron;—R. Mallet, on the Action of a Heat of 212° Fahr., when long continued, on Inorganic and Organic Substances.

Together with the Transactions of the Sections, Mr. Murchison's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE NINTH MEETING, at Birmingham, 1839, *Published at* 13*s.* 6*d.* (Out of Print.)

CONTENTS:—Rev. B. Powell, Report on the Present State of our Knowledge of Refractive Indices, for the Standard Rays of the Solar Spectrum in different media; Report on the Application of the Sum assigned for Tide Calculations to Rev. W. Whewell, in a letter from T. G. Bunt, Esq.;—H. L. Pattinson, on some Galvanic Experiments to determine the Existence or Non-Existence of Electrical Currents among Stratified Rocks, particularly those of the Mountain Limestone formation, constituting the Lead Measures of Alton Moor;—Sir D. Brewster, Reports respecting the Two Series of Hourly Meteorological Observations kept in Scotland;—Report on the subject of a series of Resolutions adopted by the British Association at their Meeting in August 1838, at Newcastle;—R. Owen, Report on British Fossil Reptiles;—E. Forbes, Report on the Distribution of the Pulmoniferous Mollusca in the British Isles;—W. S. Harris, Third Report on the Progress of the Hourly Meteorological Register at Plymouth Dockyard.

Together with the Transactions of the Sections, Rev. W. Vernon Harcourt's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TENTH MEETING, at Glasgow, 1840, *Published at* 15*s.* (Out of Print.)

CONTENTS:—Rev. B. Powell, Report on the Recent Progress of discovery relative to Radiant Heat, supplementary to a former Report on the same subject inserted in the first volume of the Reports of the British Association for the Advancement of Science;—J. D. Forbes, Supplementary Report on Meteorology;—W. S. Harris, Report on Prof. Whewell's Anemometer, now in operation at Plymouth;—Report on "The Motion and Sounds of the Heart," by the London Committee of the British Association, for 1839-40;—Prof. Schönbein, an Account of Researches in Electro-Chemistry;—R. Mallet, Second Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and at various temperatures, upon Cast Iron, Wrought Iron, and Steel;—R. W. Fox, Report on some Observations on Subterranean Temperature;—A. F. Osler, Report on the Observations recorded during the years 1837, 1838, 1839, and 1840, by the Self-registering Anemometer erected at the Philosophical Institution, Birmingham;—Sir D. Brewster, Report respecting the Two Series of Hourly Meteorological Observations kept at Inverness and Kingussie, from Nov. 1st, 1838, to Nov. 1st, 1839;—W. Thompson, Report on the Fauna of Ireland: Div. *Verte-*

brata;—C. J. B. Williams, M.D., Report of Experiments on the Physiology of the Lungs and Air-Tubes;—Rev. J. S. Henslow, Report of the Committee on the Preservation of Animal and Vegetable Substances.

Together with the Transactions of the Sections, Mr. Murchison and Major E. Sabine's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE ELEVENTH MEETING, at Plymouth, 1841, *Published at* 13*s.* 6*d.*

CONTENTS:—Rev. P. Kelland, on the Present State of our Theoretical and Experimental Knowledge of the Laws of Conduction of Heat;—G. L. Roupell, M.D., Report on Poisons;—T. G. Bunt, Report on Discussions of Bristol Tides, under the direction of the Rev. W. Whewell;—D. Ross, Report on the Discussions of Leith Tide Observations, under the direction of the Rev. W. Whewell;—W. S. Harris, upon the working of Whewell's Anemometer at Plymouth during the past year;—Report of a Committee appointed for the purpose of superintending the scientific co-operation of the British Association in the System of Simultaneous Observations in Terrestrial Magnetism and Meteorology;—Reports of Committees appointed to provide Meteorological Instruments for the use of M. Agassiz and Mr. M'Cord;—Report of a Committee appointed to superintend the Reduction of Meteorological Observations;—Report of a Committee for revising the Nomenclature of the Stars;—Report of a Committee for obtaining Instruments and Registers to record Shocks and Earthquakes in Scotland and Ireland;—Report of a Committee on the Preservation of Vegetative Powers in Seeds;—Dr. Hodgkin, on Inquiries into the Races of Man;—Report of the Committee appointed to report how far the Desiderata in our knowledge of the Condition of the Upper Strata of the Atmosphere may be supplied by means of Ascents in Balloons or otherwise, to ascertain the probable expense of such Experiments, and to draw up Directions for Observers in such circumstances;—R. Owen, Report on British Fossil Reptiles;—Reports on the Determination of the Mean Value of Railway Constants;—Dr. D. Lardner, Second and concluding Report on the Determination of the Mean Value of Railway Constants;—E. Woods, Report on Railway Constants;—Report of a Committee on the Construction of a Constant Indicator for Steam Engines.

Together with the Transactions of the Sections, Prof. Whewell's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWELFTH MEETING, at Manchester, 1842, *Published at* 10*s.* 6*d.*

CONTENTS:—Report of the Committee appointed to conduct the co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Dr. J. Richardson, Report on the present State of the Ichthyology of New Zealand;—W. S. Harris, Report on the Progress of Meteorological Observations at Plymouth;—Second Report of a Committee appointed to make Experiments on the Growth and Vitality of Seeds;—C. Vignoles, Report of the Committee on Railway Sections;—Report of the Committee for the Preservation of Animal and Vegetable Substances;—Dr. Lyon Playfair, Abstract of Prof. Liebig's Report on Organic Chemistry applied to Physiology and Pathology;—R. Owen, Report on the British Fossil Mammalia, Part I.;—R. Hunt, Researches on the Influence of Light on the Germination of Seeds and the Growth of Plants;—L. Agassiz, Report on the Fossil Fishes of the Devonian System or Old Red Sandstone;—W. Fairbairn, Appendix to a Report on the Strength and other Properties of Cast Iron obtained from the Hot and Cold Blast;—D. Milne, Report of the Committee for Registering Shocks of Earthquakes in Great Britain;—Report of a Committee on the construction of a Constant Indicator for Steam-Engines, and for the determination of the Velocity of the Piston of the Self-acting Engine at different periods of the Stroke;—J. S. Russell, Report of a Committee on the Form of Ships;—Report of a Committee appointed "to consider of the Rules by which the Nomenclature of Zoology may be established on a uniform and permanent basis;"—Report of a Committee on the Vital Statistics of Large Towns in Scotland;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Lord Francis Egerton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTEENTH MEETING, at Cork, 1843, *Published at* 12*s*.

CONTENTS:—Robert Mallet, Third Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and at Various Temperatures, upon Cast Iron, Wrought Iron, and Steel;—Report of the Committee appointed to conduct the Co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Sir J. F. W. Herschel, Bart., Report of the Committee appointed for the Reduction of Meteorological Observations;—Report of the Committee appointed for Experiments on Steam-Engines;—Report of the Committee appointed to continue their Experiments on the Vitality of Seeds;—J. S. Russell, Report of a Series of Observations on the Tides of the Frith of Forth and the East Coast of Scotland;—J. S. Russell, Notice of a Report of the Committee on the Form of Ships;—J. Blake, Report on the Physiological Action of Medicines;—Report of the Committee on Zoological Nomenclature;—Report of the Committee for Registering the Shocks of Earthquakes, and making such Meteorological Observations as may appear to them desirable;—Report of the Committee for conducting Experiments with Captive Balloons;—Prof. Wheatstone, Appendix to the Report;—Report of the Committee for the Translation and Publication of Foreign Scientific Memoirs;—C. W. Peach, on the Habits of the Marine Testacea;—E. Forbes, Report on the Mollusca and Radiata of the Ægean Sea, and on their distribution, considered as bearing on Geology;—L. Agassiz, Synoptical Table of British Fossil Fishes, arranged in the order of the Geological Formations;—R. Owen, Report on the British Fossil Mammalia, Part II.;—E. W. Binney, Report on the excavation made at the junction of the Lower New Red Sandstone with the Coal Measures at Collyhurst;—W. Thompson, Report on the Fauna of Ireland: Div. *Invertebrata;*—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, the Earl of Rosse's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FOURTEENTH MEETING, at York, 1844, *Published at* £1.

CONTENTS:—W. B. Carpenter, on the Microscopic Structure of Shells;—J. Alder and A. Hancock, Report on the British Nudibranchiate Mollusca;—R. Hunt, Researches on the Influence of Light on the Germination of Seeds and the Growth of Plants;—Report of a Committee appointed by the British Association in 1840, for revising the Nomenclature of the Stars;—Lt.-Col. Sabine, on the Meteorology of Toronto in Canada;—J. Blackwall, Report on some recent researches into the Structure, Functions, and Economy of the *Araneidea* made in Great Britain;—Earl of Rosse, on the Construction of large Reflecting Telescopes;—Rev. W. V. Harcourt, Report on a Gas-furnace for Experiments on Vitrifaction and other Applications of High Heat in the Laboratory;—Report of the Committee for Registering Earthquake Shocks in Scotland;—Report of a Committee for Experiments on Steam-Engines;—Report of the Committee to investigate the Varieties of the Human Race;—Fourth Report of a Committee appointed to continue their Experiments on the Vitality of Seeds;—W. Fairbairn, on the Consumption of Fuel and the Prevention of Smoke;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—Sixth Report of the Committee appointed to conduct the Co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Prof. Forchhammer on the influence of Fucoidal Plants upon the Formations of the Earth, on Metamorphism in general, and particularly the Metamorphosis of the Scandinavian Alum Slate;—H. E. Strickland, Report on the Recent Progress and Present State of Ornithology;—T. Oldham, Report of Committee appointed to conduct Observations on Subterranean Temperature in Ireland;—Prof. Owen, Report on the Extinct Mammals of Australia, with descriptions of certain Fossils indicative of the former existence in that continent of large Marsupial Representatives of the Order Pachydermata;—W. S. Harris, Report on the working of Whewell and Osler's Anemometers at Plymouth, for the years 1841, 1842, 1843;—W. R. Birt, Report on Atmospheric Waves;—L. Agassiz, Rapport sur les Poissons Fossiles de l'Argile de Londres, with translation;—J. S.

Russell, Report on Waves;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, the Dean of Ely's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FIFTEENTH MEETING, at Cambridge, 1845, *Published at* 12*s*.

CONTENTS:—Seventh Report of a Committee appointed to conduct the Co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Lieut.-Col. Sabine, on some Points in the Meteorology of Bombay;—J. Blake, Report on the Physiological Actions of Medicines;—Dr. Von Boguslawski, on the Comet of 1843;—R. Hunt, Report on the Actinograph;—Prof. Schönbein, on Ozone;—Prof. Erman, on the Influence of Friction upon Thermo-Electricity;—Baron Senftenberg, on the Self-registering Meteorological Instruments employed in the Observatory at Senftenberg;—W. R. Birt, Second Report on Atmospheric Waves;—G. R. Porter, on the Progress and Present Extent of Savings' Banks in the United Kingdom;—Prof. Bunsen and Dr. Playfair, Report on the Gases evolved from Iron Furnaces, with reference to the Theory of Smelting of Iron;—Dr. Richardson, Report on the Ichthyology of the Seas of China and Japan;—Report of the Committee on the Registration of Periodical Phenomena of Animals and Vegetables;—Fifth Report of the Committee on the Vitality of Seeds;—Appendix, &c.

Together with the Transactions of the Sections, Sir J. F. W. Herschel's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SIXTEENTH MEETING, at Southampton, 1846, *Published at* 15*s*.

CONTENTS:—G. G. Stokes, Report on Recent Researches in Hydrodynamics;—Sixth Report of the Committee on the Vitality of Seeds;—Dr. Schunck, on the Colouring Matters of Madder;—J. Blake, on the Physiological Action of Medicines;—R. Hunt, Report on the Actinograph;—R. Hunt, Notices on the Influence of Light on the Growth of Plants;—R. L. Ellis, on the Recent Progress of Analysis;—Prof. Forchhammer, on Comparative Analytical Researches on Sea Water;—A. Erman, on the Calculation of the Gaussian Constants for 1829;—G. R. Porter, on the Progress, present Amount, and probable future Condition of the Iron Manufacture in Great Britain;—W. R. Birt, Third Report on Atmospheric Waves;—Prof. Owen, Report on the Archetype and Homologies of the Vertebrate Skeleton;—J. Phillips, on Anemometry;—Dr. J. Percy, Report on the Crystalline Flags;—Addenda to Mr. Birt's Report on Atmospheric Waves.

Together with the Transactions of the Sections, Sir R. I. Murchison's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SEVENTEENTH MEETING, at Oxford, 1847, *Published at* 18*s*.

CONTENTS:—Prof. Langberg, on the Specific Gravity of Sulphuric Acid at different degrees of dilution, and on the relation which exists between the Development of Heat and the coincident contraction of Volume in Sulphuric Acid when mixed with Water;—R. Hunt, Researches on the Influence of the Solar Rays on the Growth of Plants;—R. Mallet, on the Facts of Earthquake Phenomena;—Prof. Nilsson, on the Primitive Inhabitants of Scandinavia;—W. Hopkins, Report on the Geological Theories of Elevation and Earthquakes;—Dr. W. B. Carpenter, Report on the Microscopic Structure of Shells;—Rev. W. Whewell and Sir James C. Ross, Report upon the Recommendation of an Expedition for the purpose of completing our Knowledge of the Tides;—Dr. Schunck, on Colouring Matters;—Seventh Report of the Committee on the Vitality of Seeds;—J. Glynn, on the Turbine or Horizontal Water-Wheel of France and Germany;—Dr. R. G. Latham, on the present state and

recent progress of Ethnographical Philology;—Dr. J. C. Prichard, on the various methods of Research which contribute to the Advancement of Ethnology, and of the relations of that Science to other branches of Knowledge;—Dr. C. C. J. Bunsen, on the results of the recent Egyptian researches in reference to Asiatic and African Ethnology, and the Classification of Languages;—Dr. C. Meyer, on the Importance of the Study of the Celtic Language as exhibited by the Modern Celtic Dialects still extant;—Dr. Max Müller, on the Relation of the Bengali to the Aryan and Aboriginal Languages of India;—W. R. Birt, Fourth Report on Atmospheric Waves;—Prof. W. H. Dove, Temperature Tables, with Introductory Remarks by Lieut.-Col. E. Sabine;—A. Erman and H. Petersen, Third Report on the Calculation of the Gaussian Constants for 1829.

Together with the Transactions of the Sections, Sir Robert Harry Inglis's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE EIGHTEENTH MEETING, at Swansea, 1848, *Published at* 9*s*.

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—J. Glynn, on Water-pressure Engines;—R. A. Smith, on the Air and Water of Towns;—Eight Report of Committee on the Growth and Vitality of Seeds;—W. R. Birt, Fifth Report on Atmospheric Waves;—E. Schunck, on Colouring Matters;—J. P. Budd, on the advantageous use made of the gaseous escape from the Blast Furnaces at the Ystalyfera Iron Works;—R. Hunt, Report of progress in the investigation of the Action of Carbonic Acid on the Growth of Plants allied to those of the Coal Formations;—Prof. H. W. Dove, Supplement to the Temperature Tables printed in the Report of the British Association for 1847;—Remarks by Prof. Dove on his recently constructed Maps of the Monthly Isothermal Lines of the Globe, and on some of the principal Conclusions in regard to Climatology deducible from them; with an introductory Notice by Lieut.-Col. E. Sabine;—Dr. Daubeny, on the progress of the investigation on the Influence of Carbonic Acid on the Growth of Ferns;—J. Phillips, Notice of further progress in Anemometrical Researches;—Mr. Mallet's Letter to the Assistant-General Secretary;—A. Erman, Second Report on the Gaussian Constants;—Report of a Committee relative to the expediency of recommending the continuance of the Toronto Magnetical and Meteorological Observatory until December 1850.

Together with the Transactions of the Sections, the Marquis of Northampton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE NINETEENTH MEETING, at Birmingham, 1849, *Published at* 10*s*.

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—Earl of Rosse, Notice of Nebulæ lately observed in the Six-feet Reflector;—Prof. Daubeny, on the Influence of Carbonic Acid Gas on the health of Plants, especially of those allied to the Fossil Remains found in the Coal Formation;—Dr. Andrews, Report on the Heat of Combination;—Report of the Committee on the Registration of the Periodic Phenomena of Plants and Animals;—Ninth Report of Committee on Experiments on the Growth and Vitality of Seeds;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from Aug. 9, 1848 to Sept. 12, 1849;—R. Mallet, Report on the Experimental Inquiry on Railway Bar Corrosion;—W. R. Birt, Report on the Discussion of the Electrical Observations at Kew.

Together with the Transactions of the Sections, the Rev. T. R. Robinson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTIETH MEETING, at Edinburgh, 1850, *Published at* 15*s*. (Out of Print.)

CONTENTS:—R. Mallet, First Report on the Facts of Earthquake Phenomena;—Rev. Prof. Powell, on Observations of Luminous Meteors;—Dr. T. Williams, on the Structure and History of the British Annelida;—T. C. Hunt, Results of Meteoro-

logical Observations taken at St. Michael's from the 1st of January, 1840, to the 31st of December, 1849;—R. Hunt, on the present State of our Knowledge of the Chemical Action of the Solar Radiations;—Tenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Major-Gen. Briggs, Report on the Aboriginal Tribes of India;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—E. Forbes, Report on the Investigation of British Marine Zoology by means of the Dredge;—R. MacAndrew, Notes on the Distribution and Range in depth of Mollusca and other Marine Animals, observed on the coasts of Spain, Portugal, Barbary, Malta, and Southern Italy in 1849;—Prof. Allman, on the Present State of our Knowledge of the Freshwater Polyzoa;—Registration of the Periodical Phenomena of Plants and Animals;—Suggestions to Astronomers for the Observation of the Total Eclipse of the Sun on July 28, 1851.

Together with the Transactions of the Sections, Sir David Brewster's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FIRST MEETING, at Ipswich, 1851, *Published* at 16*s.* 6*d.*

CONTENTS:—Rev. Prof. Powell, on Observations of Luminous Meteors;—Eleventh Report of Committee on Experiments on the Growth and Vitality of Seeds;—Dr. J. Drew, on the Climate of Southampton;—Dr. R. A. Smith, on the Air and Water of Towns: Action of Porous Strata, Water, and Organic Matter;—Report of the Committee appointed to consider the probable Effects in an Economical and Physical Point of View of the Destruction of Tropical Forests;—A. Henfrey, on the Reproduction and supposed Existence of Sexual Organs in the Higher Cryptogamous Plants;—Dr. Daubeny, on the Nomenclature of Organic Compounds;—Rev. Dr. Donaldson, on two unsolved Problems in Indo-German Philology;—Dr. T. Williams, Report on the British Annelida;—R. Mallet, Second Report on the Facts of Earthquake Phenomena;—Letter from Prof. Henry to Col. Sabine, on the System of Meteorological Observations proposed to be established in the United States;—Col. Sabine, Report on the Kew Magnetographs;—J. Welsh, Report on the Performance of his three Magnetographs during the Experimental Trial at the Kew Observatory;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from September 12, 1850, to July 31, 1851;—Ordnance Survey of Scotland.

Together with the Transactions of the Sections, Prof. Airy's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SECOND MEETING, at Belfast, 1852, *Published at* 15*s.*

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phenomena;—Twelfth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1851–52;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants;—A Manual of Ethnological Inquiry;—Col. Sykes, Mean Temperature of the Day, and Monthly Fall of Rain at 127 Stations under the Bengal Presidency;—Prof. J. D. Forbes, on Experiments on the Laws of the Conduction of Heat;—R. Hunt, on the Chemical Action of the Solar Radiations;—Dr. Hodges, on the Composition and Economy of the Flax Plant;—W. Thompson, on the Freshwater Fishes of Ulster;—W. Thompson, Supplementary Report on the Fauna of Ireland;—W. Wills, on the Meteorology of Birmingham;—J. Thomson, on the Vortex-Water-Wheel;—J. B. Lawes and Dr. Gilbert, on the Composition of Foods in relation to Respiration and the Feeding of Animals.

Together with the Transactions of the Sections, Colonel Sabine's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-THIRD MEETING, at Hull, 1853, *Published at* 10*s.* 6*d.*

CONTENTS:—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1852–53;—James Oldham, on the Physical Features of the Humber;—James Oldham, on the Rise, Progress, and Present Position of Steam Navigation in Hull;—William Fairbairn, Experimental Researches to determine the Strength of Locomotive Boilers, and the causes which lead to Explosion;—J. J. Sylvester, Provisional Report on the Theory of Determinants;—Professor Hodges, M.D., Report on the Gases evolved in Steeping Flax, and on the Composition and Economy of the Flax Plant;—Thirteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Robert Hunt, on the Chemical Action of the Solar Radiations;—Dr. John P. Bell, Observations on the Character and Measurements of Degradation of the Yorkshire Coast;—First Report of Committee on the Physical Character of the Moon's Surface, as compared with that of the Earth;—R. Mallet, Provisional Report on Earthquake Wave-Transits; and on Seismometrical Instruments;—William Fairbairn, on the Mechanical Properties of Metals as derived from repeated Meltings, exhibiting the maximum point of strength and the causes of deterioration;—Robert Mallet, Third Report on the Facts of Earthquake Phenomena (continued).

Together with the Transactions of the Sections, Mr. Hopkins's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FOURTH MEETING, at Liverpool, 1854, *Published at* 18*s.*

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phenomena (continued);—Major-General Chesney, on the Construction and General Use of Efficient Life-Boats;—Rev. Prof. Powell, Third Report on the present State of our Knowledge of Radiant Heat;—Colonel Sabine, on some of the results obtained at the British Colonial Magnetic Observatories;—Colonel Portlock, Report of the Committee on Earthquakes, with their proceedings respecting Seismometers;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants, Part 2;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1853–54;—Second Report of the Committee on the Physical Character of the Moon's Surface;—W. G. Armstrong, on the Application of Water-Pressure Machinery;—J. B. Lawes and Dr. Gilbert, on the Equivalency of Starch and Sugar in Food;—Archibald Smith, on the Deviations of the Compass in Wooden and Iron Ships;—Fourteenth Report of Committee on Experiments on the Growth and Vitality of Seeds.

Together with the Transactions of the Sections, the Earl of Harrowby's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FIFTH MEETING, at Glasgow, 1855, *Published at* 15*s.*

CONTENTS:—T. Dobson, Report on the Relation between Explosions in Coal-Mines and Revolving Storms;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants growing under different Atmospheric Conditions, Part 3;—C. Spence Bate, on the British Edriophthalma;—J. F. Bateman, on the present state of our knowledge on the Supply of Water to Towns;—Fifteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1854–55;—Report of Committee appointed to inquire into the best means of ascertaining those properties of Metals and effects of various modes of treating them which are of importance to the durability and efficiency of Artillery;—Rev. Prof. Henslow, Report on Typical Objects in Natural History;—A. Follett Osler, Account of the Self-registering Anemometer and Rain-Gauge at the Liverpool Observatory;—Provisional Reports.

Together with the Transactions of the Sections, the Duke of Argyll's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SIXTH MEETING, at Cheltenham, 1856, *Published at* 18*s*.

CONTENTS:—Report from the Committee appointed to investigate and report upon the effects produced upon the Channels of the Mersey by the alterations which within the last fifty years have been made in its Banks;—J. Thomson, Interim Report on progress in Researches on the Measurement of Water by Weir Boards;—Dredging Report, Frith of Clyde, 1856;—Rev. B. Powell, Report on Observations of Luminous Meteors, 1855–1856;—Prof. Bunsen and Dr. H. E. Roscoe, Photochemical Researches;—Rev. James Booth, on the Trigonometry of the Parabola, and the Geometrical Origin of Logarithms;—R. MacAndrew, Report on the Marine Testaceous Mollusca of the North-east Atlantic and neighbouring Seas, and the physical conditions affecting their development;—P. P. Carpenter, Report on the present state of our knowledge with regard to the Mollusca of the West Coast of North America;—T. C. Eyton, Abstract of First Report on the Oyster Beds and Oysters of the British Shores;—Prof. Phillips, Report on Cleavage, and Foliation in Rocks, and on the Theoretical Explanations of these Phenomena, Part 1;—Dr. T. Wright, on the Stratigraphical Distribution of the Oolitic Echinodermata;—W. Fairbairn, on the Tensile Strength of Wrought Iron at various Temperatures;—C. Atherton, on Mercantile Steam Transport Economy;—J. S. Bowerbank, on the Vital Powers of the Spongiadæ;—Report of a Committee upon the Experiments conducted at Stormontfield, near Perth, for the artificial propagation of Salmon;—Provisional Report on the Measurement of Ships for Tonnage;—On Typical Forms of Minerals, Plants and Animals for Museums;—J. Thomson, Interim Report on Progress in Researches on the Measurement of Water by Weir Boards;—R. Mallet, on Observations with the Seismometer;—A. Cayley, on the Progress of Theoretical Dynamics;—Report of a Committee appointed to consider the formation of a Catalogue of Philosophical Memoirs.

Together with the Transactions of the Sections, Dr. Daubeny's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SEVENTH MEETING, at Dublin, 1857, *Published at* 15*s*.

CONTENTS:—A. Cayley, Report on the recent progress of Theoretical Dynamics;—Sixteenth and Final Report of Committee on Experiments on the Growth and Vitality of Seeds;—James Oldham, C.E., continuation of Report on Steam Navigation at Hull;—Report of a Committee on the Defects of the present methods of Measuring and Registering the Tonnage of Shipping, as also of Marine Engine-Power, and to frame more perfect rules, in order that a correct and uniform principle may be adopted to estimate the Actual Carrying Capabilities and Working-power of Steam Ships;—Robert Were Fox, Report on the Temperature of some Deep Mines in Cornwall;—Dr. G. Plarr, de quelques Transformations de la Somme $\Sigma_0^t \frac{a^{t|}+^1\beta^{t|}+^1\delta^{t|}+^1}{1^t+^1\gamma^t+^1\epsilon^t+^1}^{-\alpha}$ a étant entier négatif, et de quelques cas dans lesquels cette somme est exprimable par une combinaison de factorielles, la notation $a^{t|}+^1$ désignant le produit des facteurs α $(\alpha+1)$ $(\alpha+2)$ &c.... $(\alpha+t-1)$;—G. Dickie, M.D., Report on the Marine Zoology of Strangford Lough, County Down, and corresponding part of the Irish Channel;—Charles Atherton, Suggestions for Statistical Inquiry into the Extent to which Mercantile Steam Transport Economy is effected by the Constructive Type of Shipping, as respects the Proportions of Length, Breadth, and Depth;—J. S. Bowerbank, Further Report on the Vitality of the Spongiadæ;—Dr. John P. Hodges, on Flax;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain;—Rev. Baden Powell, Report on Observations of Luminous Meteors, 1856–57;—C. Vignoles, on the Adaptation of Suspension Bridges to sustain the passage of Railway Trains;—Prof. W. A. Miller, on Electro-Chemistry;—John Simpson, Results of Thermometrical Observations made at the *Plover's* Wintering-place, Point Barrow, latitude 71° 21′ N., long. 156° 17′ W., in 1852–54;—Charles James Hargreave, on the Algebraic Couple; and on the Equivalents of Indeterminate Expressions;—Thomas Grubb, Report on the Improvement of Telescope and Equatorial Mountings;—Prof. James Buckman, Report on the Experimental Plots

in the Botanical Garden of the Royal Agricultural College at Cirencester;—William Fairbairn, on the Resistance of Tubes to Collapse;—George C. Hyndman, Report of the Proceedings of the Belfast Dredging Committee;—Peter W. Barlow, on the Mechanical Effect of combining Girders and Suspension Chains, and a Comparison of the Weight of Metal in Ordinary and Suspension Girders, to produce equal deflections with a given load;—J. Park Harrison, Evidences of Lunar Influence on Temperature;—Report on the Animal and Vegetable Products imported into Liverpool from the year 1851 to 1855 (inclusive);—Andrew Henderson, Report on the Statistics of Life-boats and Fishing-boats on the Coasts of the United Kingdom.

Together with the Transactions of the Sections, the Rev. H. Lloyd's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-EIGHTH MEETING, at Leeds, September 1858, *Published at* 20*s*.

CONTENTS:—R. Mallet, Fourth Report upon the Facts and Theory of Earthquake Phenomena;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1857, 1858;—R. H. Meade, on some Points in the Anatomy of the Araneidea or true Spiders, especially on the internal structure of their Spinning Organs;—W. Fairbairn, Report of the Committee on the Patent Laws;—S. Eddy, on the Lead Mining Districts of Yorkshire;—W. Fairbairn, on the Collapse of Glass Globes and Cylinders;—Dr. E. Perceval Wright and Prof. J. Reay Greene, Report on the Marine Fauna of the South and West Coasts of Ireland;—Prof. J. Thomson, on Experiments on the Measurement of Water by Triangular Notches in Weir Boards;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain;—Michael Connel and William Keddie, Report on Animal, Vegetable, and Mineral Substances imported from Foreign Countries into the Clyde (including the Ports of Glasgow, Greenock, and Port Glasgow) in the years 1853, 1854, 1855, 1856, and 1857;—Report of the Committee on Shipping Statistics;—Rev. H. Lloyd, D.D., Notice of the Instruments employed in the Magnetic Survey of Ireland, with some of the Results;—Prof. J. R. Kinahan, Report of Dublin Dredging Committee, appointed 1857-58;—Prof. J. R. Kinahan, Report on Crustacea of Dublin District;—Andrew Henderson, on River Steamers, their Form, Construction, and Fittings, with reference to the necessity for improving the present means of Shallow-Water Navigation on the Rivers of British India;—George C. Hyndman, Report of the Belfast Dredging Committee;—Appendix to Mr. Vignoles' Paper "On the Adaptation of Suspension Bridges to sustain the passage of Railway Trains;"—Report of the Joint Committee of the Royal Society and the British Association, for procuring a continuance of the Magnetic and Meteorological Observatories;—R. Beckley, Description of a Self-recording Anemometer.

Together with the Transactions of the Sections, Prof. Owen's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-NINTH MEETING, at Aberdeen, September 1859, *Published at* 15*s*.

CONTENTS:—George C. Foster, Preliminary Report on the Recent Progress and Present State of Organic Chemistry;—Professor Buckman, Report on the Growth of Plants in the Garden of the Royal Agricultural College, Cirencester;—Dr. A. Voelcker, Report on Field Experiments and Laboratory Researches on the Constituents of Manures essential to Cultivated Crops;—A. Thomson, of Banchory, Report on the Aberdeen Industrial Feeding Schools;—On the Upper Silurians of Lesmahagow, Lanarkshire;—Alphonse Gages, Report on the Results obtained by the Mechanico-Chemical Examination of Rocks and Minerals;—William Fairbairn, Experiments to determine the Efficiency of Continuous and Self-acting Breaks for Railway Trains;—Professor J. R. Kinahan, Report of Dublin Bay Dredging Committee for 1858-59;—Rev. Baden Powell, Report on Observations of Luminous Meteors for 1858-59;—Professor Owen, Report on a Series of Skulls of various Tribes of Mankind inhabiting Nepal, collected, and presented to the British Museum, by Bryan H. Hodgson, Esq., late Resident in Nepal, &c., &c.;—Messrs. Maskelyne, Hadow, Hardwich, and Llewelyn, Report on the Present State of our Knowledge regarding the Photographic Image;—

G. C. Hyndman, Report of the Belfast Dredging Committee for 1859;—James Oldham, Continuation of Report of the Progress of Steam Navigation at Hull;—Charles Atherton, Mercantile Steam Transport Economy as affected by the Consumption of Coals;—Warren De La Rue, Report on the present state of Celestial Photography in England;—Professor Owen, on the Orders of Fossil and Recent Reptilia, and their Distribution in Time;—Balfour Stewart, on some Results of the Magnetic Survey of Scotland in the years 1857 and 1858, undertaken, at the request of the British Association, by the late John Welsh, Esq., F.R.S.;—W. Fairbairn, The Patent Laws: Report of Committee on the Patent Laws;—J. Park Harrison, Lunar Influence on the Temperature of the Air:—Balfour Stewart, an Account of the Construction of the Self-recording Magnetographs at present in operation at the Kew Observatory of the British Association;—Professor H. J. Stephen Smith, Report on the Theory of Numbers, Part I.;—Report of the Committee on Steamship Performance;—Report of the Proceedings of the Balloon Committee of the British Association appointed at the Meeting at Leeds;—Prof. William K. Sullivan, Preliminary Report on the Solubility of Salts at Temperatures above 100° Cent., and on the Mutual Action of Salts in Solution.

Together with the Transactions of the Sections, Prince Albert's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTIETH MEETING, at Oxford, June and July 1860, *Published at* 15*s*.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors, 1859–60;—J. R. Kinahan, Report of Dublin Bay Dredging Committee;—Rev. J. Anderson, Report on the Excavations in Dura Den;—Prof. Buckman, Report on the Experimental Plots in the Botanical Garden of the Royal Agricultural College, Cirencester;—Rev. R. Walker, Report of the Committee on Balloon Ascents;—Prof. W. Thomson, Report of Committee appointed to prepare a Self-recording Atmospheric Electrometer for Kew, and Portable Apparatus for observing Atmospheric Electricity;—William Fairbairn, Experiments to determine the Effect of Vibratory Action and long-continued Changes of Load upon Wrought-iron Girders;—R. P. Greg, Catalogue of Meteorites and Fireballs, from A.D. 2 to A.D. 1860;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part II.;—Vice-Admiral Moorsom, on the Performance of Steam-vessels, the Functions of the Screw, and the Relations of its Diameter and Pitch to the Form of the Vessel;—Rev. W. V. Harcourt, Report on the Effects of long-continued Heat, illustrative of Geological Phenomena;—Second Report of the Committee on Steamship Performance;—Interim Report on the Gauging of Water by Triangular Notches;—List of the British Marine Invertebrate Fauna.

Together with the Transactions of the Sections, Lord Wrottesley's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FIRST MEETING, at Manchester, September 1861, *Published at* £1.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors;—Dr. E. Smith, Report on the Action of Prison Diet and Discipline on the Bodily Functions of Prisoners, Part I.;—Charles Atherton, on Freight as affected by Differences in the Dynamic Properties of Steamships;—Warren De La Rue, Report on the Progress of Celestial Photography since the Aberdeen Meeting;—B. Stewart, on the Theory of Exchanges, and its recent extension;—Drs. E. Schunck, R. Angus Smith, and H. E. Roscoe, on the Recent Progress and Present Condition of Manufacturing Chemistry in the South Lancashire District;—Dr. J. Hunt, on Ethno-Climatology; or, the Acclimatization of Man;—Prof. J. Thomson, on Experiments on the Gauging of Water by Triangular Notches;—Dr. A. Voelcker, Report on Field Experiments and Laboratory Researches on the Constituents of Manures essential to cultivated Crops;—Prof. H. Hennessy, Provisional Report on the Present State of our Knowledge respecting the Transmission of Sound-signals during Fogs at Sea;—Dr. P. L. Sclater and F. von Hochstetter, Report on the Present State of our Knowledge of the Birds of the Genus *Apteryx* living in New Zealand;—J. G. Jeffreys, Report of the Results of Deep-sea Dredging in Zetland, with a Notice of several Species of Mollusca new to Science or to the British Isles;—Prof. J. Phillips, Contributions to a Report on

the Physical Aspect of the Moon;—W. R. Birt, Contribution to a Report on the Physical Aspect of the Moon;—Dr. Collingwood and Mr. Byerley, Preliminary Report of the Dredging Committee of the Mersey and Dee;—Third Report of the Committee on Steamship Performance;—J. G. Jeffreys, Preliminary Report on the Best Mode of preventing the Ravages of *Teredo* and other Animals in our Ships and Harbours;—R. Mallet, Report on the Experiments made at Holyhead to ascertain the Transit-Velocity of Waves, analogous to Earthquake Waves, through the local Rock Formations;—T. Dobson, on the Explosions in British Coal-Mines during the year 1859;—J. Oldham, Continuation of Report on Steam Navigation at Hull;—Prof. G. Dickie, Brief Summary of a Report on the Flora of the North of Ireland;—Prof. Owen, on the Psychical and Physical Characters of the Mincopies, or Natives of the Andaman Islands, and on the Relations thereby indicated to other Races of Mankind;—Colonel Sykes, Report of the Balloon Committee;—Major-General Sabine, Report on the Repetition of the Magnetic Survey of England;—Interim Report of the Committee for Dredging on the North and East Coasts of Scotland;—W. Fairbairn, on the Resistance of Iron Plates to Statical Pressure and the Force of Impact by Projectiles at High Velocities;—W. Fairbairn, Continuation of Report to determine the effect of Vibratory Action and long-continued Changes of Load upon Wrought-Iron Girders;—Report of the Committee on the Law of Patents;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part III.

Together with the Transactions of the Sections, Mr. Fairbairn's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-SECOND MEETING at Cambridge, October 1862, *Published at* £1.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors, 1861–62;—G. B. Airy, on the Strains in the Interior of Beams;—Archibald Smith and F. J. Evans, Report on the three Reports of the Liverpool Compass Committee;—Report on Tidal Observations on the Humber;—T. Aston, on Rifled Guns and Projectiles adapted for Attacking Armour-plate Defences;—Extracts, relating to the Observatory at Kew, from a Report presented to the Portuguese Government, by Dr. J. A. de Souza;—H. T. Mennell, Report on the Dredging of the Northumberland Coast and Dogger Bank;—Dr. Cuthbert Collingwood, Report upon the best means of advancing Science through the agency of the Mercantile Marine;—Messrs. Williamson, Wheatstone, Thomson, Miller, Matthiessen, and Jenkin, Provisional Report on Standards of Electrical Resistance;—Preliminary Report of the Committee for investigating the Chemical and Mineralogical Composition of the Granites of Donegal;—Prof. H. Hennessy, on the Vertical Movements of the Atmosphere considered in connection with Storms and Changes of Weather;—Report of Committee on the application of Gauss's General Theory of Terrestrial Magnetism to the Magnetic Variations;—Fleeming Jenkin, on Thermo-electric Currents in Circuits of one Metal;—W. Fairbairn, on the Mechanical Properties of Iron Projectiles at High Velocities;—A. Cayley, Report on the Progress of the Solution of certain Special Problems of Dynamics;—Prof. G. G. Stokes, Report on Double Refraction;—Fourth Report of the Committee on Steamship Performance;—G. J. Symons, on the Fall of Rain in the British Isles in 1860 and 1861;—J. Ball, on Thermometric Observations in the Alps;—J. G. Jeffreys, Report of the Committee for Dredging on the North and East Coasts of Scotland;—Report of the Committee on Technical and Scientific Evidence in Courts of Law;—James Glaisher, Account of Eight Balloon Ascents in 1862;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part IV.

Together with the Transactions of the Sections, the Rev. Prof. R. Willis's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-THIRD MEETING, at Newcastle-upon-Tyne, August and September 1863, *Published at* £1 5*s*.

CONTENTS:—Report of the Committee on the Application of Gun-cotton to Warlike Purposes;—A. Matthiessen, Report on the Chemical Nature of Alloys;—Report of the Committee on the Chemical and Mineralogical Constitution of the Granites of Donegal, and on the Rocks associated with them;—J. G. Jeffreys, Report of the Committee appointed for Exploring the Coasts of Shetland by means of the Dredge;—

G. D. Gibb, Report on the Physiological Effects of the Bromide of Ammonium;—C. K. Aken, on the Transmutation of Spectral Rays, Part I.;—Dr. Robinson, Report of the Committee on Fog Signals;—Report of the Committee on Standards of Electrical Resistance;—E. Smith, Abstract of Report by the Indian Government on the Foods used by the Free and Jail Populations in India;—A. Gages, Synthetical Researches on the Formation of Minerals, &c.;—R. Mallet, Preliminary Report on the Experimental Determination of the Temperatures of Volcanic Foci, and of the Temperature, State of Saturation, and Velocity of the issuing Gases and Vapours;—Report of the Committee on Observations of Luminous Meteors;—Fifth Report of the Committee on Steamship Performance;—G. J. Allman, Report on the Present State of our Knowledge of the Reproductive System in the Hydroida;—J. Glaisher, Account of Five Balloon Ascents made in 1863;—P. P. Carpenter, Supplementary Report on the Present State of our Knowledge with regard to the Mollusca of the West Coast of North America;—Prof. Airy, Report on Steam Boiler Explosions;—C. W. Siemens, Observations on the Electrical Resistance and Electrification of some Insulating Materials under Pressures up to 300 Atmospheres;—C. M. Palmer, on the Construction of Iron Ships and the Progress of Iron Shipbuilding on the Tyne, Wear, and Tees;—Messrs. Richardson, Stevenson, and Clapham, on the Chemical Manufactures of the Northern Districts;—Messrs. Sopwith and Richardson, on the Local Manufacture of Lead, Copper, Zinc, Antimony, &c.;—Messrs. Daglish and Forster, on the Magnesian Limestone of Durham;—I. L. Bell, on the Manufacture of Iron in connexion with the Northumberland and Durham Coal-field;—T. Spencer, on the Manufacture of Steel in the Northern District;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part V.

Together with the Transactions of the Sections, Sir William Armstrong's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FOURTH MEETING, at Bath, September 1864, *Published at* 18*s*.

CONTENTS:—Report of the Committee for Observations of Luminous Meteors;—Report of the Committee on the best means of providing for a Uniformity of Weights and Measures;—T. S. Cobbold, Report of Experiments respecting the Development and Migration of the Entozoa;—B. W. Richardson, Report on the Physiological Action of Nitrite of Amyl;—J. Oldham, Report of the Committee on Tidal Observations;—G. S. Brady, Report on Deep-sea Dredging on the Coasts of Northumberland and Durham in 1864;—J. Glaisher, Account of Nine Balloon Ascents made in 1863 and 1864;—J. G. Jeffreys, Further Report on Shetland Dredgings;—Report of the Committee on the Distribution of the Organic Remains of the North Staffordshire Coal-field;—Report of the Committee on Standards of Electrical Resistance;—G. J. Symons, on the Fall of Rain in the British Isles in 1862 and 1863;—W. Fairbairn, Preliminary Investigation of the Mechanical Properties of the proposed Atlantic Cable.

Together with the Transactions of the Sections, Sir Charles Lyell's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FIFTH MEETING, at Birmingham, September 1865, *Published at* £1 5*s*.

CONTENTS:—J. G. Jeffreys, Report on Dredging among the Channel Isles;—F. Buckland, Report on the Cultivation of Oysters by Natural and Artificial Methods;—Report of the Committee for exploring Kent's Cavern;—Report of the Committee on Zoological Nomenclature;—Report on the Distribution of the Organic Remains of the North Staffordshire Coal-field;—Report on the Marine Fauna and Flora of the South Coast of Devon and Cornwall;—Interim Report on the Resistance of Water to Floating and Immersed Bodies;—Report on Observations of Luminous Meteors;—Report on Dredging on the Coast of Aberdeenshire;—J. Glaisher, Account of Three Balloon Ascents;—Interim Report on the Transmission of Sound under Water;—G. J. Symons, on the Rainfall of the British Isles;—W. Fairbairn, on the Strength of Materials considered in relation to the Construction of Iron Ships;—Report of the Gun-Cotton Committee;—A. F. Osler, on the Horary and Diurnal Variations in the Direction and Motion of the Air at Wrottesley, Liverpool, and

Birmingham;—B. W. Richardson, Second Report on the Physiological Action of certain of the Amyl Compounds;—Report on further Researches in the Lingula-flags of South Wales;—Report of the Lunar Committee for Mapping the Surface of the Moon;—Report on Standards of Electrical Resistance;—Report of the Committee appointed to communicate with the Russian Government respecting Magnetical Observations at Tiflis;—Appendix to Report on the Distribution of the Vertebrate Remains from the North Staffordshire Coal-field;—H. Woodward, First Report on the Structure and Classification of the Fossil Crustacea;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part VI.;—Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the interests of Science;—A. G. Findlay, on the Bed of the Ocean;—Prof. A. W. Williamson, on the Composition of Gases evolved by the Bath Spring called King's Bath.

Together with the Transactions of the Sections, Prof. Phillips's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-SIXTH MEETING, at Nottingham, August 1866, *Published at* £1 4*s*.

CONTENTS:—Second Report on Kent's Cavern, Devonshire;—A. Matthiessen, Preliminary Report on the Chemical Nature of Cast Iron;—Report on Observations of Luminous Meteors;—W. S. Mitchell, Report on the Alum Bay Leaf-bed;—Report on the Resistance of Water to Floating and Immersed Bodies;—Dr. Norris, Report on Muscular Irritability;—Dr. Richardson, Report on the Physiological Action of certain compounds of Amyl and Ethyl;—H. Woodward, Second Report on the Structure and Classification of the Fossil Crustacea;—Second Report on the "Menevian Group," and the other Formations at St. David's, Pembrokeshire;—J. G. Jeffreys, Report on Dredging among the Hebrides;—Rev. A. M. Norman, Report on the Coasts of the Hebrides, Part II.;—J. Alder, Notices of some Invertebrata, in connexion with Mr. Jeffreys's Report;—G. S. Brady, Report on the *Ostracoda* dredged amongst the Hebrides;—Report on Dredging in the Moray Firth;—Report on the Transmission of Sound-Signals under Water;—Report of the Lunar Committee;—Report of the Rainfall Committee;—Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the Interests of Science;—J. Glaisher, Account of Three Balloon Ascents;—Report on the Extinct Birds of the Mascarene Islands;—Report on the Penetration of Iron-clad Ships by Steel Shot;—J. A. Wanklyn, Report on Isomerism among the Alcohols;—Report on Scientific Evidence in Courts of Law;—A. L. Adams, Second Report on Maltese Fossiliferous Caves, &c.

Together with the Transactions of the Sections, Mr. Grove's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-SEVENTH MEETING, at Dundee, September 1867, *Published at* £1 6*s*.

CONTENTS:—Report of the Committee for Mapping the Surface of the Moon;—Third Report on Kent's Cavern, Devonshire;—On the present State of the Manufacture of Iron in Great Britain;—Third Report on the Structure and Classification of the Fossil Crustacea;—Report on the Physiological Action of the Methyl Compounds;—Preliminary Report on the Exploration of the Plant-Beds of North Greenland;—Report of the Steamship Performance Committee;—On the Meteorology of Port Louis, in the Island of Mauritius;—On the Construction and Works of the Highland Railway;—Experimental Researches on the Mechanical Properties of Steel;—Report on the Marine Fauna and Flora of the South Coast of Devon and Cornwall;—Supplement to a Report on the Extinct Didine Birds of the Mascarene Islands;—Report on Observations of Luminous Meteors;—Fourth Report on Dredging among the Shetland Isles;—Preliminary Report on the Crustacea, &c., procured by the Shetland Dredging Committee in 1867;—Report on the Foraminifera obtained in the Shetland Seas;—Second Report of the Rainfall Committee;—Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the interests of Science;—Report on Standards of Electrical Resistance.

Together with the Transactions of the Sections, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-EIGHTH MEETING, at Norwich, August 1868, *Published at* £1 5*s*.

CONTENTS:—Report of the Lunar Committee;—Fourth Report on Kent's Cavern, Devonshire;—On Puddling Iron;—Fourth Report on the Structure and Classification of the Fossil Crustacea;—Report on British Fossil Corals;—Report on Spectroscopic Investigations of Animal Substances;—Report of Steamship Performance Committee;—Spectrum Analysis of the Heavenly Bodies;—On Stellar Spectrometry;—Report on the Physiological Action of the Methyl and allied Compounds;—Report on the Action of Mercury on the Biliary Secretion;—Last Report on Dredging among the Shetland Isles;—Reports on the Crustacea, &c., and on the Annelida and Foraminifera from the Shetland Dredgings;—Report on the Chemical Nature of Cast Iron, Part I.;—Interim Report on the Safety of Merchant Ships and their Passengers;—Report on Observations of Luminous Meteors;—Preliminary Report on Mineral Veins containing Organic Remains;—Report on the Desirability of Explorations between India and China;—Report of Rainfall Committee;—Report on Synthetical Researches on Organic Acids;—Report on Uniformity of Weights and Measures;—Report of the Committee on Tidal Observations;—Report of the Committee on Underground Temperature;—Changes of the Moon's Surface;—Report on Polyatomic Cyanides.

Together with the Transactions of the Sections, Dr. Hooker's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-NINTH MEETING, at Exeter, August 1869, *Published at* £1 2*s*.

CONTENTS:—Report on the Plant-beds of North Greenland;—Report on the existing knowledge on the Stability, Propulsion, and Sea-going qualities of Ships;—Report on Steam-boiler Explosions;—Preliminary Report on the Determination of the Gases existing in Solution in Well-waters;—The Pressure of Taxation on Real Property;—On the Chemical Reactions of Light discovered by Prof. Tyndall;—On Fossils obtained at Kiltorkan Quarry, co. Kilkenny;—Report of the Lunar Committee;—Report on the Chemical Nature of Cast Iron;—Report on the Marine Fauna and Flora of the South Coast of Devon and Cornwall;—Report on the Practicability of establishing "a Close Time" for the Protection of Indigenous Animals;—Experimental Researches on the Mechanical Properties of Steel;—Second Report on British Fossil Corals;—Report of the Committee appointed to get cut and prepared Sections of Mountain-Limestone Corals for Photographing;—Report on the Rate of Increase of Underground Temperature;—Fifth Report on Kent's Cavern, Devonshire;—Report on the Connexion between Chemical Constitution and Physiological Action;—On Emission, Absorption, and Reflection of Obscure Heat;—Report on Observations of Luminous Meteors;—Report on Uniformity of Weights and Measures;—Report on the Treatment and Utilization of Sewage;—Supplement to Second Report of the Steamship-Performance Committee;—Report on Recent Progress in Elliptic and Hyperelliptic Functions;—Report on Mineral Veins in Carboniferous Limestone and their Organic Contents;—Notes on the Foraminifera of Mineral Veins and the Adjacent Strata;—Report of the Rainfall Committee;—Interim Report on the Laws of the Flow and Action of Water containing Solid Matter in Suspension;—Interim Report on Agricultural Machinery;—Report on the Physiological Action of Methyl and Allied Series;—On the Influence of Form considered in Relation to the Strength of Railway-axles and other portions of Machinery subjected to Rapid Alterations of Strain;—On the Penetration of Armour-plates with Long Shells of Large Capacity fired obliquely;—Report on Standards of Electrical Resistance.

Together with the Transactions of the Sections, Prof. Stokes's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTIETH MEETING, at Liverpool, September 1870, *Published at* 18*s*.

CONTENTS:—Report on Steam-boiler Explosions;—Report of the Committee on the Hæmatite Iron-ores of Great Britain and Ireland;—Report on the Sedimentary Deposits of the River Onny;—Report on the Chemical Nature of Cast Iron;—Report on the practicability of establishing a "Close Time" for the protection of Indigenous Animals;—Report on Standards of Electrical Resistance;—Sixth Report on Kent's Cavern;—Third Report on Underground Temperature;—Second Report of the Committee appointed to get cut and prepared Sections of Mountain-Limestone Corals;—Second Report on the Stability, Propulsion, and Sea-going Qualities of Ships;—Report on Earthquakes in Scotland;—Report on the Treatment and Utilization of Sewage;—Report on Observations of Luminous Meteors, 1869–70;—Report on Recent Progress in Elliptic and Hyperelliptic Functions;—Report on Tidal Observations;—On a new Steam-power Meter;—Report on the Action of the Methyl and Allied Series;—Report of the Rainfall Committee;—Report on the Heat generated in the Blood in the Process of Arterialization;—Report on the best means of providing for Uniformity of Weights and Measures.

Together with the Transactions of the Sections, Prof. Huxley's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-FIRST MEETING, at Edinburgh, August 1871, *Published at* 16*s*.

CONTENTS:—Seventh Report on Kent's Cavern;—Fourth Report on Underground Temperature;—Report on Observations of Luminous Meteors, 1870–71;—Fifth Report on the Structure and Classification of the Fossil Crustacea;—Report of the Committee appointed for the purpose of urging on Her Majesty's Government the expediency of arranging and tabulating the results of the approaching Census in the three several parts of the United Kingdom in such a manner as to admit of ready and effective comparison;—Report of the Committee appointed for the purpose of Superintending the Publication of Abstracts of Chemical Papers;—Report of the Committee for discussing Observations of Lunar Objects suspected of change;—Second Provisional Report on the Thermal Conductivity of Metals;—Report on the Rainfall of the British Isles;—Third Report on the British Fossil Corals;—Report on the Heat generated in the Blood during the Process of Arterialization;—Report of the Committee appointed to consider the subject of Physiological Experimentation;—Report on the Physiological Action of Organic Chemical Compounds;—Report of the Committee appointed to get cut and prepared Sections of Mountain-Limestone Corals;—Second Report on Steam-Boiler Explosions;—Report on the Treatment and Utilization of Sewage;—Report on promoting the Foundation of Zoological Stations in different parts of the World;—Preliminary Report on the Thermal Equivalents of the Oxides of Chlorine;—Report on the practicability of establishing a "Close Time" for the protection of Indigenous Animals;—Report on Earthquakes in Scotland;—Report on the best means of providing for a Uniformity of Weights and Measures;—Report on Tidal Observations.

Together with the Transactions of the Sections, Sir William Thomson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-SECOND MEETING, at Brighton, August 1872, *Published at* £1 4*s*.

CONTENTS:—Report on the Gaussian Constants for the Year 1829;—Second Supplementary Report on the Extinct Birds of the Mascarene Islands;—Report of the Committee for Superintending the Monthly Reports of the Progress of Chemistry;—Report of the Committee on the best means of providing for a Uniformity of Weights and Measures;—Eighth Report on Kent's Cavern;—Report on promoting the Foundation of Zoological Stations in different parts of the World;—Fourth Report on the Fauna of South Devon;—Preliminary Report of the Committee appointed to Construct and Print Catalogues of Spectral Rays arranged upon a Scale of Wave-numbers;—Third Report on Steam-Boiler Explosions;—Report on Observations of

Luminous Meteors, 1871–72;—Experiments on the Surface-friction experienced by a Plane moving through Water;—Report of the Committee on the Antagonism between the Action of Active Substances;—Fifth Report on Underground Temperature;—Preliminary Report of the Committee on Siemens's Electrical-Resistance Pyrometer;—Fourth Report on the Treatment and Utilization of Sewage;—Interim Report of the Committee on Instruments for Measuring the Speed of Ships and Currents;—Report on the Rainfall of the British Isles;—Report of the Committee on a Geographical Exploration of the Country of Moab;—Sur l'élimination des Fonctions Arbitraires;—Report on the Discovery of Fossils in certain remote parts of the North-western Highlands;—Report of the Committee on Earthquakes in Scotland;—Fourth Report on Carboniferous-Limestone Corals;—Report of the Committee to consider the mode in which new Inventions and Claims for Reward in respect of adopted Inventions are examined and dealt with by the different Departments of Government;—Report of the Committee for discussing Observations of Lunar Objects suspected of change;—Report on the Mollusca of Europe;—Report of the Committee for investigating the Chemical Constitution and Optical Properties of Essential Oils;—Report on the practicability of establishing a "Close Time" for the preservation of Indigenous Animals;—Sixth Report on the Structure and Classification of Fossil Crustacea;—Report of the Committee appointed to organize an Expedition for observing the Solar Eclipse of Dec. 12, 1871;—Preliminary Report of a Committee on Terato-embryological Inquiries;—Report on Recent Progress in Elliptic and Hyperelliptic Functions;—Report on Tidal Observations;—On the Brighton Waterworks;—On Amsler's Planimeter.

Together with the Transactions of the Sections, Dr. Carpenter's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-THIRD MEETING, at Bradford, September 1873, *Published at* £1 5*s*.

CONTENTS:—Report of the Committee on Mathematical Tables;—Observations on the Application of Machinery to the Cutting of Coal in Mines;—Concluding Report on the Maltese Fossil Elephants;—Report of the Committee for ascertaining the Existence in different parts of the United Kingdom of any Erratic Blocks or Boulders;—Fourth Report on Earthquakes in Scotland;—Ninth Report on Kent's Cavern;—On the Flint and Chert Implements found in Kent's Cavern;—Report of the Committee for Investigating the Chemical Constitution and Optical Properties of Essential Oils;—Report of Inquiry into the Method of making Gold-assays;—Fifth Report on the Selection and Nomenclature of Dynamical and Electrical Units;—Report of the Committee on the Labyrinthodonts of the Coal-measures;—Report of the Committee appointed to construct and print Catalogues of Spectral Rays;—Report of the Committee appointed to explore the Settle Caves;—Sixth Report on Underground Temperature;—Report on the Rainfall of the British Isles;—Seventh Report on Researches in Fossil Crustacea;—Report on Recent Progress in Elliptic and Hyperelliptic Functions;—Report on the desirability of establishing a "Close Time" for the preservation of Indigenous Animals;—Report on Luminous Meteors;—On the Visibility of the Dark Side of Venus;—Report of the Committee for the Foundation of Zoological Stations in different parts of the World;—Second Report of the Committee for collecting Fossils from North-western Scotland;—Fifth Report on the Treatment and Utilization of Sewage;—Report of the Committee on Monthly Reports of the Progress of Chemistry;—On the Bradford Waterworks;—Report on the possibility of Improving the Methods of Instruction in Elementary Geometry;—Interim Report of the Committee on Instruments for Measuring the Speed of Ships, &c.;—Report of the Committee for Determinating High Temperatures by means of the Refrangibility of Light evolved by Fluid or Solid Substances;—On a periodicity of Cyclones and Rainfall in connexion with Sun-spot Periodicity;—Fifth Report on the Structure of Carboniferous-Limestone Corals;—Report of the Committee on preparing and publishing brief forms of Instructions for Travellers, Ethnologists, &c.;—Preliminary Note from the Committee on the Influence of Forests on the Rainfall;—Report of the Sub-Wealden Exploration Committee;—Report of the Committee on Machinery for obtaining a Record of the Roughness of the Sea and Measurement of Waves near shore;—Report on Science Lectures and Organization;—Second Report on Science Lectures and Organization.

Together with the Transactions of the Sections, Prof. A. W. Williamson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-FOURTH MEETING, at Belfast, August 1874, *Published at* £1 5*s*.

CONTENTS:—Tenth Report on Kent's Cavern;—Report for investigating the Chemical Constitution and Optical Properties of Essential Oils;—Second Report of the Sub-Wealden Exploration Committee;—On the Recent Progress and Present State of Systematic Botany;—Report of the Committee for investigating the Nature of Intestinal Secretion;—Report of the Committee on the Teaching of Physics in Schools;—Preliminary Report for investigating Isomeric Cresols and their Derivatives;—Third Report of the Committee for collecting Fossils from localities in North-western Scotland;—Report on the Rainfall of the British Isles;—On the Belfast Harbour;—Report of Inquiry into the Method of making Gold-assays;—Report of a Committee on Experiments to determine the Thermal Conductivities of certain Rocks;—Second Report on the Exploration of the Settle Caves;—On the Industrial uses of the Upper Bann River;—Report of the Committee on the Structure and Classification of the Labyrinthodont;—Second Report of the Committee for recording the position, height above the sea, lithological characters, size, and origin of the Erratic Blocks of England and Wales, &c.;—Sixth Report on the Treatment and Utilization of Sewage;—Report on the Anthropological Notes and Queries for the use of Travellers;—On Cyclone and Rainfall Periodicities;—Fifth Report on Earthquakes in Scotland;—Report of the Committee appointed to prepare and print Tables of Wave-numbers;—Report of the Committee for testing the new Pyrometer of Mr. Siemens;—Report to the Lords Commissioners of the Admiralty on Experiments for the Determination of the Frictional Resistance of Water on a Surface, &c.;—Second Report for the Selection and Nomenclature of Dynamical and Electrical Units;—On Instruments for measuring the Speed of Ships;—Report of the Committee on the possibility of establishing a "Close Time" for the Protection of Indigenous Animals;—Report of the Committee to inquire into the economic effects of Combinations of Labourers and Capitalists;—Preliminary Report on Dredging on the Coasts of Durham and North Yorkshire;—Report on Luminous Meteors;—Report on the best means of providing for a Uniformity of Weights and Measures.

Together with the Transactions of the Sections, Prof. John Tyndall's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-FIFTH MEETING, at Bristol, August 1875, *Published at* £1 5*s*.

CONTENTS:—Eleventh Report on Kent's Cavern;—Seventh Report on Underground Temperature;—Report on the Zoological Station at Naples;—Report of a Committee appointed to inquire into the Methods employed in the Estimation of Potash and Phosphoric Acid in Commercial Products;—Report on the present state of our Knowledge of the Crustacea;—Second Report on the Thermal Conductivities of certain Rocks;—Preliminary Report of the Committee for extending the Observations on the Specific Volumes of Liquids;—Sixth Report on Earthquakes in Scotland;—Seventh Report on the Treatment and Utilization of Sewage;—Report of the Committee for furthering the Palestine Explorations;—Third Report of the Committee for recording the position, height above the sea, lithological characters, size, and origin of the Erratic Blocks of England and Wales, &c.;—Report of the Rainfall Committee;—Report of the Committee for investigating Isomeric Cresols and their Derivatives;—Report of the Committee for investigating the Circulation of the Underground Waters in the New Red Sandstone and Permian Formations of England;—On the Steering of Screw-Steamers;—Second Report of the Committee on Combinations of Capital and Labour;—Report on the Method of making Gold-assays;—Eighth Report on Underground Temperature;—Tides in the River Mersey;—Sixth Report of the Committee on the Structure of Carboniferous Corals;—Report of the Committee appointed to explore the Settle Caves;—On the River Avon (Bristol), its Drainage-Area, &c.;—Report of the Committee on the possibility of establishing a "Close Time" for the Protection of Indigenous Animals;—Report of the Committee appointed to superintend the Publication of the Monthly Reports of the Progress of Chemistry;—Report on Dredging off the Coasts of Durham and North Yorkshire in 1874;—Report on Luminous Meteors;—On the Analytical Forms called Trees;—Report of the Committee on Mathematical

Tables;—Report of the Committee on Mathematical Notation and Printing;—Second Report of the Committee for investigating Intestinal Secretion;—Third Report of the Sub-Wealden Exploration Committee.

Together with the Transactions of the Sections, Sir John Hawkshaw's Address and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-SIXTH MEETING, at Glasgow, September 1876, *Published at* £1 5*s.*

CONTENTS:—Twelfth Report on Kent's Cavern;—Report on Improving the Methods of Instruction in Elementary Geometry;—Results of a Comparison of the British-Association Units of Electrical Resistance;—Third Report on the Thermal Conductivities of certain Rocks;—Report of the Committee on the practicability of adopting a Common Measure of Value in the Assessment of Direct Taxation;—Report of the Committee for testing experimentally Ohm's Law;—Report of the Committee on the possibility of establishing a "Close Time" for the Protection of Indigenous Animals;—Report of the Committee on the Effect of Propellers on the Steering of Vessels;—On the Investigation of the Steering Qualities of Ships;—Seventh Report on Earthquakes in Scotland;—Report on the present state of our Knowledge of the Crustacea;—Second Report of the Committee for investigating the Circulation of the Underground Waters in the New Red Sandstone and Permian Formations of England;—Fourth Report of the Committee on the Erratic Blocks of England and Wales, &c.;—Fourth Report of the Committee on the Exploration of the Settle Caves (Victoria Cave);—Report on Observations of Luminous Meteors, 1875–76;—Report on the Rainfall of the British Isles, 1875–76;—Ninth Report on Underground Temperature;—Nitrous Oxide in the Gaseous and Liquid States;—Eighth Report on the Treatment and Utilization of Sewage;—Improved Investigations on the Flow of Water through Orifices, with Objections to the modes of treatment commonly adopted;—Report of the Anthropometric Committee;—On Cyclone and Rainfall Periodicities in connexion with the Sun-spot Periodicity;—Report of the Committee for determining the Mechanical Equivalent of Heat;—Report of the Committee on Tidal Observations;—Third Report of the Committee on the Conditions of Intestinal Secretion and Movement;—Report of the Committee for collecting and suggesting subjects for Chemical Research.

Together with the Transactions of the Sections, Dr. T. Andrews's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-SEVENTH MEETING, at Plymouth, August 1877, *Published at* £1 4*s.*

CONTENTS:—Thirteenth Report on Kent's Cavern;—Second and Third Reports on the Methods employed in the estimation of Potash and Phosphoric Acid in Commercial Products;—Report on the present state of our Knowledge of the Crustacea (Part III.);—Third Report on the Circulation of the Underground Waters in the New Red Sandstone and Permian Formations of England;—Fifth Report on the Erratic Blocks of England, Wales, and Ireland;—Fourth Report on the Thermal Conductivities of certain Rocks;—Report on Observations of Luminous Meteors, 1876–77;—Tenth Report on Underground Temperature;—Report on the Effect of Propellers on the Steering of Vessels;—Report on the possibility of establishing a "Close Time" for the Protection of Indigenous Animals;—Report on some Double Compounds of Nickel and Cobalt;—Fifth Report on the Exploration of the Settle Caves (Victoria Cave);—Report on the Datum Level of the Ordnance Survey of Great Britain;—Report on the Zoological Station at Naples;—Report of the Anthropometric Committee;—Report on the Conditions under which Liquid Carbonic Acid exists in Rocks and Minerals.

Together with the Transactions of the Sections, Prof. Allen Thomson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-EIGHTH MEETING, at Dublin, August 1878, *Published at* £1 4*s.*

CONTENTS:—Catalogue of the Oscillation-Frequencies of Solar Rays;—Report on Mr. Babbage's Analytical Machine;—Third Report of the Committee for determining the Mechanical Equivalent of Heat;—Report of the Committee for arranging for the taking of certain Observations in India, and Observations on Atmospheric Electricity at Madeira;—Report on the commencement of Secular Experiments upon the Elasticity of Wires;—Report on the Chemistry of some of the lesser-known Alkaloids, especially Veratria and Bebeerine;—Report on the best means for the Development of Light from Coal-Gas;—Fourteenth Report on Kent's Cavern;—Report on the Fossils in the North-west Highlands of Scotland;—Fifth Report on the Thermal Conductivities of certain Rocks;—Report on the possibility of establishing a 'Close Time' for the Protection of Indigenous Animals;—Report on the occupation of a Table at the Zoological Station at Naples;—Report of the Anthropometric Committee;—Report on Patent Legislation;—Report on the Use of Steel for Structural Purposes;—Report on the Geographical Distribution of the Chiroptera;—Recent Improvements in the Port of Dublin;—Report on Mathematical Tables;—Eleventh Report on Underground Temperature;—Report on the Exploration of the Fermanagh Caves;—Sixth Report on the Erratic Blocks of England, Wales, and Ireland;—Report on the present state of our Knowledge of the Crustacea (Part IV.);—Report on two Caves in the neighbourhood of Tenby;—Report on the Stationary Tides in the English Channel and in the North Sea, &c.;—Second Report on the Datum-level of the Ordnance Survey of Great Britain;—Report on Instruments for measuring the Speed of Ships;—Report of Investigations into a Common Measure of Value in Direct Taxation;—Report on Sunspots and Rainfall;—Report on Observations of Luminous Meteors;—Sixth Report on the Exploration of the Settle Caves (Victoria Cave);—Report on the Kentish Boring Exploration;—Fourth Report on the Circulation of Underground Waters in the Jurassic, New Red Sandstone, and Permian Formations, with an Appendix on the Filtration of Water through Triassic Sandstone;—Report on the Effect of Propellers on the Steering of Vessels.

Together with the Transactions of the Sections, Mr. Spottiswoode's Address, and Recommendations of the Association and its Committees.

BRITISH ASSOCIATION

FOR

THE ADVANCEMENT OF SCIENCE.

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CORRECTED TO OCTOBER 8, 1879.

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1879.

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§§ indicates Annual Subscribers who will be entitled to the Report if their Subscriptions are paid by December 31, 1879.
‡ indicates Subscribers not entitled to the Annual Report.
Names without any mark before them are Life Members not entitled to the Annual Report.
Names of Members of the GENERAL COMMITTEE are printed in SMALL CAPITALS.
Names of Members whose addresses are incomplete or not known are in *italics*.

Notice of changes of Residence should be sent to the Assistant Secretary, 22 Albemarle Street, London, W.

Year of Election.

Abbatt, Richard, F.R.A.S. Marlborough House, Burgess Hill, Sussex.
1866. ‡Abbott, George J., United States Consul, Sheffield and Nottingham.
1863. *ABEL, FREDERICK AUGUSTUS, C.B., F.R.S., F.C.S., Director of the Chemical Establishment of the War Department, Royal Arsenal, Woolwich.
1856. ‡Abercrombie, John, M.D. 13 Suffolk-square, Cheltenham.
1863. *Abernethy, James. 4 Delahay-street, Westminster, London, S.W.
1873. ‡Abernethy, James. Ferry-hill, Aberdeen.
1860. ‡Abernethy, Robert. Ferry-hill, Aberdeen.
1873. *ABNEY, Captain W. de W., R.E., F.R.S., F.R.A.S., F.C.S. 3 St. Alban's-road, Kensington, London, W.
1854. ‡Abraham, John. 87 Bold-street, Liverpool.
1877. ‡Ace, Rev. Daniel, D.D. Laughton, near Gainsborough, Lincolnshire.
1873. ‡Ackroyd, Samuel. Greaves-street, Little Horton, Bradford, Yorkshire.
1869. ‡Acland, Charles T. D. Sprydoncote, Exeter.
1877. *Acland, Francis E. Dyke, R.A. Oxford.
1873. *Acland, Rev. H. D. Loughton, Essex.
ACLAND, HENRY W. D., M.A., M.D., LL.D., F.R.S., F.R.G.S., Radcliffe Librarian and Regius Professor of Medicine in the University of Oxford. Broad-street, Oxford.
1877. *Acland, Theodore Dyke, M.A. 13 Vincent-square, Westminster, S.W.
1860. ‡ACLAND, Sir THOMAS DYKE, Bart., M.A., D.C.L., M.P. Sprydoncote, Exeter; and Athenæum Club, London, S.W.

Year of Election.

Adair, John. 13 Merrion-square North, Dublin.

1872. ‡Adams, A. Leith, M.A., M.B., F.R.S., F.G.S., Professor of Zoology, Royal College of Science for Ireland. 18 Clarendon-gardens, Maida Hill, W.; and Junior United Service Club, Charles-street, St. James's, London, S.W.

1876. ‡Adams, James. 9 Royal-crescent West, Glasgow.

*Adams, John Couch, M.A., LL.D., F.R.S., F.R.A.S., Director of the Observatory and Lowndsean Professor of Astronomy and Geometry in the University of Cambridge. The Observatory, Cambridge.

1871. §Adams, John R. 3 College-gardens, Dulwich, Surrey, S.E.

1879. §Adams, Rev. Thomas, M.A. Clifton Green House, York.

1877. ‡Adams, William. 3 Sussex-terrace, Plymouth.

1869. *Adams, William Grylls, M.A., F.R.S., F.G.S., F.C.P.S., Professor of Natural Philosophy and Astronomy in King's College, London. 43 Notting Hill-square, London, W.

1873. ‡Adams-Acton, John. Margutta House, 103 Marylebone-road, London, N.W.

1879. §Adamson, Robert, M.A., Professor of Logic and Political Economy in Owens College, Manchester. 60 Parsonage-road, Withington, Manchester.

Adderley, The Right Hon. Sir Charles Bowyer, M.P. Hamshall, Coleshill, Warwickshire.

Adelaide, The Right Rev. Augustus Short, D.D., Bishop of. South Australia.

1860. **Adie, Patrick. Grove Cottage, Barnes, London, S.W.*

1865. *Adkins, Henry. Northfield, near Birmingham.

1864. *Ainsworth, David. The Flosh, Cleator, Carnforth.

1871. *Ainsworth, John Stirling. The Flosh, Cleator, Carnforth.

Ainsworth, Peter. Smithills Hall, Bolton.

1842. *Ainsworth, Thomas. The Flosh, Cleator, Carnforth.

1871. ‡Ainsworth, William M. The Flosh, Cleator, Carnforth.

1859. ‡Airlie, The Right Hon. the Earl of, K.T. Holly Lodge, Campden Hill, London, W.; and Airlie Castle, Forfarshire.

Airy, Sir George Biddell, K.C.B., M.A., LL.D., D.C.L., F.R.S., F.R.A.S., Astronomer Royal. The Royal Observatory, Greenwich, S.E.

1871. §Aitken, John, F.R.S.E. Darroch, Falkirk, N.B.

Akroyd, Edward. Bankfield, Halifax.

1862. ‡Alcock, Sir Rutherford, K.C.B., D.C.L., F.R.G.S. The Athenæum Club, Pall Mall, London, S.W.

1861. ‡Alcock, Thomas, M.D. Side Brook, Salemoor, Manchester.

1872. *Alcock, Thomas, M.D. Oakfield, Ashton-on-Mersey, Manchester.

*Aldam, William. Frickley Hall, near Doncaster.

Alderson, Sir James, M.A., M.D., D.C.L., F.R.S., Consulting Physician to St. Mary's Hospital. 17 Berkeley-square, London, W.

1859. ‡Alexander, General Sir James Edward, K.C.B., K.C.L.S., F.R.S.E., F.R.A.S., F.R.G.S. Westerton, Bridge of Allan, N.B.

1873. ‡Alexander, Reginald, M.D. 13 Hallfield-road, Bradford, Yorkshire.

1858. ‡Alexander, William, M.D. Halifax.

1850. ‡Alexander, Rev. William Lindsay, D.D., F.R.S.E. Pinkieburn, Musselburgh, by Edinburgh.

1867. ‡Alison, George L. C. Dundee.

1859. ‡Allan, Alexander. Scottish Central Railway, Perth.

1871. ‡Allan, G., C.E. 17 Leadenhall-street, London, E.C.

1871. §Allen, Alfred H., F.C.S. 1 Surrey-street, Sheffield.

1879. *Allen, A. J. C. Peterhouse, Cambridge.

Year of Election.

1878. §§Allen, John Romilly. 5 Albert-terrace, Regent's Park, London, N.W.
1861. †Allen, Richard. Didsbury, near Manchester.
Allen, William. 50 Henry-street, Dublin.
1852. *Allen, William J. C., Secretary to the Royal Belfast Academical Institution. Ulster Bank, Belfast.
1863. †Allhusen, C. Elswick Hall, Newcastle-on-Tyne.
*Allman, George J., M.D., LL.D., F.R.S. L. & E., M.R.I.A., Pres. L.S., Emeritus Professor of Natural History in the University of Edinburgh. (President.) Queen Anne's Mansions, St. James's Park, London, S.W.; and Parkstone, Dorset.
1875. *Alston, Edward R., F.L.S., F.Z.S. 22A Dorset-street, Portman-square, London, W.
1873. †Ambler, John. North Park-road, Bradford, Yorkshire.
1876. †Anderson, Alexander. 1 St. James's-place, Hillhead, Glasgow.
1878. §§Anderson, Beresford. Saint Ville, Killiney.
1850. †Anderson, Charles William. Cleadon, South Shields.
1850. †Anderson, John. 31 St. Bernard's-crescent, Edinburgh.
1874. †Anderson, John, J.P., F.G.S. Holywood, Belfast.
1876. †Anderson, Matthew. 137 St. Vincent-street, Glasgow.
1859. †Anderson, Patrick. 15 King-street, Dundee.
1875. †Anderson, Captain S., R.E. Junior United Service Club, Charles-street, St. James's, London, S.W.
1870. †*Anderson, Thomas Darnley. West Dingle, Liverpool.*
*Andrews, Thomas, M.D., LL.D., F.R.S., Hon. F.R.S.E., M.R.I.A., F.C.S. Belfast.
1857. †Andrews, William. The Hill, Monkstown, Co. Dublin.
1877. §Angell, John. 81 Ducie-grove, Oxford-street, Manchester.
1859. †Angus, John. Town House, Aberdeen.
1878. §§Anson, Frederick H. 9 Delahay-street, Westminster, S.W.
*Ansted, David Thomas, M.A., F.R.S., F.G.S., F.R.G.S. 1 Prince's-street, Storey's-gate, Westminster, S.W.; and Melton, Suffolk.
Anthony, John, M.D. 6 Greenfield-crescent, Edgbaston, Birmingham.
Apjohn, James, M.D., F.R.S., F.C.S., M.R.I.A., Professor of Mineralogy at Dublin University. South Hill, Blackrock, Co. Dublin.
1868. †Appleby, C. J. Emerson-street, Bankside, Southwark, London, S.E.
1870. †Archer, Francis, jun. 3 Brunswick-street, Liverpool.
1855. *Archer, Professor Thomas C., F.R.S.E., Director of the Museum of Science and Art, Edinburgh. West Newington House, Edinburgh.
1874. †Archer, William, F.R.S., M.R.I.A. St. Brendan's, Grosvenor-road East, Rathmines, Dublin.
1851. †Argyll, His Grace the Duke of, K.T., D.C.L., F.R.S. L. & E., F.G.S. Argyll Lodge, Kensington, London, W.; and Inverary, Argyleshire.
1865. †*Armitage, J. W., M.D. 9 Huntriss-row, Scarborough.*
1861. †Armitage, William. 95 Portland-street, Manchester.
1867. *Armitstead, George. Errol Park, Errol, N.B.
1879. *Armstrong, Sir Alexander, K.C.B., LL.D., F.R.S. The Albany, London, W.
1873. §§Armstrong, Henry E., Ph.D., F.R.S., F.C.S. London Institution, Finsbury-circus, London, E.C.
1878. †Armstrong, James. 28A Renfield-street, Glasgow.
1874. †*Armstrong, James T., F.C.S. Plym Villa, Clifton-road, Tuebrook, Liverpool.*
Armstrong, Thomas. Higher Broughton, Manchester.

Year of Election.

1857. *Armstrong, Sir William George, C.B., LL.D., D.C.L., F.R.S. 8 Great George-street, London, S.W.; and Jesmond Dene, Newcastle-upon-Tyne.
1871. ‡Arnot, William, F.C.S. St. Margaret's, Kirkintilloch, N.B.
1870. ‡Arnott, Thomas Reid. Bramshill, Harlesden Green, London, N.W.
1853. *Arthur, Rev. William, M.A. Clapham Common, London, S.W.
1870. *Ash, Dr. T. Linnington. Holsworthy, North Devon.
1874. ‡Ashe, Isaac, M.B. District Asylum, Londonderry.
1873. §§Ashton, John. Gorse Bank House, Windsor-road, Oldham.
1842. *Ashton, Thomas, M.D. 8 Royal Wells-terrace, Cheltenham.
Ashton, Thomas. Ford Bank, Didsbury, Manchester.
1866. ‡Ashwell, Henry. Mount-street, New Basford, Nottingham.
*Ashworth, Edmund. Egerton Hall, Bolton-le-Moors.
Ashworth, Henry. Turton, near Bolton.
1861. ‡Aspland, Alfred. Dukinfield, Ashton-under-Lyne.
1875. *Aspland, W. Gaskell. Aghadowey, near Ballymoney, Ireland.
1861. §Asquith, J. R. Infirmary-street, Leeds.
1861. ‡Aston, Theodore. 11 New-square, Lincoln's Inn, London, W.C.
1872. §Atchison, Arthur T., M.A. 60 Warwick-road, Earl's Court, London, S.W.
1873. ‡*Atchison, D. G. Tyersall Hall, Yorkshire.*
1858. ‡Atherton, Charles. Sandover, Isle of Wight.
1866. ‡*Atherton, J. H., F.C.S. Long-row, Nottingham.*
1865. ‡Atkin, Alfred. Griffin's Hill, Birmingham.
1861. ‡Atkin, Eli. Newton Heath, Manchester.
1865. *Atkinson, Edmund, Ph.D., F.C.S. Portesbery Hill, Camberley, Surrey.
1863. *Atkinson, G. Clayton. 21 Windsor-terrace, Newcastle-on-Tyne.
1861. ‡Atkinson, Rev. J. A. Longsight Rectory, near Manchester.
1858. *Atkinson, John Hastings. 12 East Parade, Leeds.
1842. *Atkinson, Joseph Beavington. Stratford House, 113 Abingdon-road, Kensington, London, W.
1858. Atkinson, William. Claremont, Southport.
1863. *Attfield, Professor J., Ph.D., F.C.S. 17 Bloomsbury-square, London, W.C.
1860. *Austin-Gourlay, Rev. William E. C., M.A. The Rectory, Stanton St. John, near Oxford.
1865. *Avery, Thomas. Church-road, Edgbaston, Birmingham.
1867. ‡Avison, Thomas, F.S.A. Fulwood Park, Liverpool.
1878. *Aylmer, Sir Gerald George, Bart. Donadea Castle, Kilcock, Co. Kildare.
1877. *Ayrton, W. E. 98 Palace-gardens-terrace, Kensington, London, W.
1853. *Ayrton, W. S., F.S.A. Cliffden, Saltburn-by-the-Sea.

*Babington, Charles Cardale, M.A., F.R.S., F.L.S., F.G.S., Professor of Botany in the University of Cambridge. 5 Brookside, Cambridge.
Backhouse, Edmund. Darlington.
Backhouse, Thomas James. Sunderland.
1863. ‡Backhouse, T. W. West Hendon House, Sunderland.
1877. ‡Badock, W. F. Badminton House, Clifton Park, Bristol.
1870. §§Bailey, Dr. F. J. 51 Grove-street, Liverpool.
1878. §§Bailey, John. 3 Blackhall-place, Dublin.
1865. ‡Bailey, Samuel, F.G.S. The Peck, Walsall.
1855. ‡Bailey, William. Horseley Fields Chemical Works, Wolverhampton.
1866. ‡Baillon, Andrew. St. Mary's Gate, Nottingham.
1866. ‡Baillon, L. St. Mary's Gate, Nottingham.

Year of Election.

1878. §§Baily, Walter. 176 Haverstock-hill, London, N.W.
1857. ‡Baily, William Hellier, F.L.S., F.G.S., Acting Palæontologist to the Geological Survey of Ireland. 14 Hume-street; and Apsley Lodge, 92 Rathgar-road, Dublin.
1873. §Bain, Sir James. 3 Park-terrace, Glasgow.
1865. ‡Bain, Rev. W. J. Glenlark Villa, Leamington.
*Bainbridge, Robert Walton. Middleton House, Middleton-in-Teesdale, by Darlington.
*Baines, Edward. Belgrave Mansions, Grosvenor-gardens, London, S.W.; and St. Ann's Hill, Burley, Leeds.
1858. ‡Baines, Frederick. Burley, near Leeds.
1858. ‡Baines, T. Blackburn. 'Mercury' Office, Leeds.
1866. ‡Baker, Francis B. Sherwood-street, Nottingham.
1865. ‡Baker, James P. Wolverhampton.
1861. *Baker, John. Gatley Hill, Cheadle, Manchester.
1865. ‡Baker, Robert L. Barham House, Leamington.
1849. *Baker, William. 63 Gloucester-place, Hyde Park, London, W.
1863. ‡Baker, William. 6 Taptonville, Sheffield.
1875. *Baker, W. Mills. Moorland House, Stoke Bishop, near Bristol.
1875. ‡Baker, W. Proctor. Brislington, Bristol.
1871. *Balfour, Francis Maitland, M.A., F.R.S. Trinity College, Cambridge.
1871. ‡Balfour, G. W. Whittinghame, Prestonkirk, Scotland.
1875. §§Balfour, Isaac Bayley, D.Sc. 27 Inverleith-row, Edinburgh.
*Balfour, John Hutton, M.D., M.A., F.R.S. L. & E., F.L.S. Inverleith House, Edinburgh.
1878. *Ball, Charles Bent, M.D. 16 Great Fitzwilliam-street, Dublin.
*Ball, John, M.A., F.R.S., F.L.S., M.R.I.A. 10 Southwell-gardens, South Kensington, London, S.W.
1866. *Ball, Robert Stawell, M.A., LL.D., F.R.S., F.R.A.S., Andrews Professor of Astronomy in the University of Dublin, and Royal Astronomer. The Observatory, Dunsink, Co. Dublin.
1878. §Ball, Valentine, M.A., F.G.S. Calcutta. (Care of Messrs. S. H. King & Co., Pall Mall, London, S.W.)
*Ball, William. Bruce-grove, Tottenham, London; and Glen Rothay, near Ambleside, Westmoreland.
1876. ‡*Ballantyne, James. Southcroft, Rutherglen, Glasgow.*
1870. ‡Balmain, William H., F.C.S. Spring Cottage, Great St. Helen's, Lancashire.
1869. ‡Bamber, Henry K., F.C.S. 5 Westminster-chambers, Victoria-street, Westminster, S.W.
1874. *Bangay, Frederick Arthur. Cheadle, Cheshire.
1852. ‡Bangor, Viscount. Castleward, Co. Down, Ireland.
1879. §Banham, H. French. Mount View, Glossop-road, Sheffield.
1870. ‡Banister, Rev. William, B.A. St. James's Mount, Liverpool.
1861. ‡*Bannermann, James Alexander. Limefield House, Higher Broughton, near Manchester.*
1866. ‡Barber, John. Long-row, Nottingham.
1861. *Barbour, George. Bankhead, Broxton, Chester.
1859. ‡Barbour, George F. 11 George-square, Edinburgh.
*Barbour, Robert. Bolesworth Castle, Tattenhall, Chester.
1855. ‡Barclay, Andrew. Kilmarnock, Scotland.
Barclay, Charles, F.S.A. Bury Hill, Dorking.
1871. ‡Barclay, George. 17 Coates-crescent, Edinburgh.
1852. *Barclay, J. Gurney. 54 Lombard-street, London, E.C.
1860. *Barclay, Robert. High Leigh, Hoddesden, Herts.
1876. *Barclay, Robert. 21 Park-terrace, Glasgow.

Year of Election.

1868. *Barclay, W. L. 54 Lombard-street, London, E.C.
1863. *Barford, James Gale, F.C.S. Wellington College, Wokingham, Berkshire.
1860. *Barker, Rev. Arthur Alcock, B.D. East Bridgford Rectory, Nottingham.
1879. §Barker, Elliott. 2 High-street, Sheffield.
1857. ‡Barker, John, M.D., Curator of the Royal College of Surgeons of Ireland. 83 Waterloo-road, Dublin.
1879. *Barker, Rev. Philip C., M.A., LL.B. Rotherham, Yorkshire.
1865. ‡Barker, Stephen. 30 Frederick-street, Edgbaston, Birmingham.
1870. ‡Barkly, Sir Henry, K.C.B., F.R.S., F.R.G.S. 25 Queen's-gate-terrace, London, S.W.
1873. ‡Barlow, Crawford, B.A. 2 Old Palace-yard, Westminster, S.W.
1878.§§Barlow, John, M.D. The University, Glasgow.
Barlow, Lieut.-Col. Maurice (14th Regt. of Foot). 5 Great George-street, Dublin.
Barlow, Peter. 10 Lower Mount-street, Dublin.
1857. ‡Barlow, Peter William, F.R.S., F.G.S. 26 Great George-street, Westminster, S.W.
1873.§§Barlow, W. H., C.E., F.R.S. 2 Old Palace-yard, Westminster, S.W.
1861. *Barnard, Major R. Cary, F.L.S. Bartlow, Leckhampton, Cheltenham.
1868.§§Barnes, Richard H. (Care of Messrs. Collyer, 4 Bedford-row, London, W.C.)
Barnes, Thomas Addison. Grove Park, Wrexham.
*Barnett, Richard, M.R.C.S. 3 Heath-terrace, Leamington.
1859. ‡Barr, Lieut.-General. Apsleytoun, East Grinstead, Sussex.
1861. *Barr, William R., F.G.S. Fernside, Cheadle Hulme, Cheshire.
1860. ‡Barrett, T. B. High-street, Welshpool, Montgomery.
1872. *Barrett, W. F., F.R.S.E., M.R.I.A., F.C.S., Professor of Physics in the Royal College of Science, Dublin.
1874. ‡Barrington, R. M. Fassaroe, Bray, Co. Wicklow.
1874. §Barrington-Ward, Mark J., M.A., F.L.S., F.R.G.S., H.M. Inspector of Schools. 2 St. George's Square, Worcester.
1866. ‡Barron, William. Elvaston Nurseries, Borrowash, Derby.
1858. ‡Barry, Rev. Canon, D.D., D.C.L., Principal of King's College, London, W.C.
1862. *Barry, Charles. 15 Pembridge-square, Bayswater, London, W.
1875. ‡Barry, John Wolfe. 23 Delahay-street, Westminster, S.W.
Barstow, Thomas. Garrow Hill, near York.
1858. *Bartholomew, Charles. Castle Hill House, Ealing, Middlesex, W.
1855. ‡Bartholomew, Hugh. New Gasworks, Glasgow.
1858. *Bartholomew, William Hamond. Ridgeway House, Cumberland-road, Headingley, Leeds.
1873.§§Bartley, George C. T. National Penny Bank, 270 Oxford-street, London, W.
1868. *Barton, Edward (27th Inniskillens). Clonelly, Ireland.
1857. ‡Barton, Folloit W. Clonelly, Co. Fermanagh.
1852. ‡Barton, James. Farndreg, Dundalk.
1864. ‡Bartrum, John S. 41 Gay-street, Bath.
*Bashforth, Rev. Francis, B.D. Minting Vicarage, near Horncastle.
1876. ‡Bassano, Alexander. 12 Montagu-place, London, W.
1876. ‡Bassano, Clement. Jesus College, Cambridge.
1866. *Bassett, Henry. 26 Belitha-villas, Barnsbury, London, N.
1866. ‡Bassett, Richard. Pelham-street, Nottingham.

Year of Election.

1869. ‡Bastard, S. S. Summerland-place, Exeter.
1871. ‡Bastian, H. Charlton, M.D., M.A., F.R.S., F.L.S., Professor of Pathological Anatomy at University College. 20 Queen Anne-street, London, W.
1848. ‡Bate, C. Spence, F.R.S., F.L.S. 8 Mulgrave-place, Plymouth.
1873. *Bateman, Daniel. Low Moor, near Bradford, Yorkshire.
1868. ‡Bateman, Frederick, M.D. Upper St. Giles's-street, Norwich.
Bateman, James, M.A., F.R.S., F.R.G.S., F.L.S. 9 Hyde Park-gate South, London, W.
1842. *Bateman, John Frederic, C.E., F.R.S., F.G.S., F.R.G.S. 16 Great George-street, London, S.W.
1864. ‡Bates, Henry Walter, Assist.-Sec. R.G.S., F.L.S. 1 Savile-row, London, W.
1852. ‡Bateson, Sir Robert, Bart. Belvoir Park, Belfast.
1851. ‡Bath and Wells, The Right Rev. Lord Arthur Hervey, Lord Bishop of. The Palace, Wells, Somerset.
1869. ‡Batten, John Winterbotham. 35 Palace-gardens-terrace, Kensington, London, W.
1863. §Bauerman, H., F.G.S. 41 Acre-lane, Brixton, London, S.W.
1861. ‡Baxendell, Joseph, F.R.A.S. 108 Stock-street, Manchester.
1867. ‡Baxter, Edward. Hazel Hall, Dundee.
1867. ‡Baxter, John B. Craig Tay House, Dundee.
1867. ‡Baxter, The Right Hon. William Edward, M.P. Ashcliffe, Dundee.
1868. ‡Bayes, William, M.D. 58 Brook-street, London, W.
1851. *Bayley, George. 16 London-street, Fenchurch-street, London, E.C.
1866. ‡Bayley, Thomas. Lenton, Nottingham.
1854. ‡*Baylis, C. O., M.D.* 22 *Devonshire-road, Claughton, Birkenhead.*
Bayly, John. Seven Trees, Plymouth.
1875. *Bayly, Robert. Torr-grove, near Plymouth.
1876. *Baynes, Robert E., M.A. Christ Church, Oxford.
Bazley, Thomas Sebastian, M.A. Hatherop Castle, Fairford, Gloucestershire.
1860. *Beale, Lionel S., M.D., F.R.S., Professor of Pathological Anatomy in King's College. 61 Grosvenor-street, London, W.
1872. ‡Beanes, Edward, F.C.S. The White House, North Dulwich, Surrey, S.E.
1870. ‡Beard, Rev. Charles. 13 South-hill-road, Toxteth Park, Liverpool.
*Beatson, William. Chemical Works, Rotherham.
1855. *Beaufort, W. Morris, F.R.A.S., F.R.G.S., F.M.S., F.S.S. 18 Piccadilly, London, W.
1861. *Beaumont, Rev. Thomas George. Chelmondiston Rectory, Ipswich.
1871. *Beazley, Major George G., F.R.G.S. 16 Holles-street, Cavendish-square, London, W.
1859. *Beck, Joseph, F.R.A.S. 31 Cornhill, London, E.C.
1864. §Becker, Miss Lydia E. Whalley Range, Manchester.
1860. ‡Beckles, Samuel H., F.R.S., F.G.S. 9 Grand-parade, St. Leonard's-on-Sea.
1866. ‡Beddard, James. Derby-road, Nottingham.
1870. §Beddoe, John, M.D., F.R.S. Clifton, Bristol.
1878. §§Bedson, P. Phillips, D.Sc. Oak Leigh, Marple, near Stockport.
1873. ‡Behrens, Jacob. Springfield House, North-parade, Bradford, Yorkshire.
1874. ‡Belcher, Richard Boswell. Blockley, Worcestershire.
1873. §§Bell, A. P. Royal Exchange, Manchester.

Year of Election.

1871. §Bell, Charles B. 6 Spring-bank, Hull.
Bell, Frederick John. Woodlands, near Maldon, Essex.
1859. ‡Bell, George. Windsor-buildings, Dumbarton.
1860. ‡Bell, Rev. George Charles, M.A. Marlborough College, Wilts.
1855. ‡Bell, Capt. Henry. Chalfont Lodge, Cheltenham.
1879. §Bell, Henry S. Kenwood Bank, Sharrow, Sheffield.
1862. *Bell, Isaac Lowthian, M.P., F.R.S., F.C.S., M.I.C.E. Rounton Grange, Northallerton.
1875. §§Bell, James, F.C.S. The Laboratory, Somerset House, London, W.C.
1871. *Bell, J. Carter, F.C.S. Kersal Clough, Higher Broughton, Manchester.
1853. ‡Bell, John Pearson, M.D. Waverley House, Hull.
1864. ‡Bell, R. Queen's College, Kingston, Canada.
1876. §Bell, R. Bruce. 2 Clifton-place, Glasgow.
Bell, Thomas, F.R.S., F.L.S., F.G.S. The Wakes, Selborne, near Alton, Hants.
1863. *Bell, Thomas. Crosby Court, Northallerton.
1867. ‡Bell, Thomas. Belmont, Dundee.
1875. ‡Bell, William. 36 Park-road, New Wandsworth, Surrey, S.W.
1842. Bellhouse, Edward Taylor. Eagle Foundry, Manchester.
1854. ‡*Bellhouse, William Dawson.* 1 *Park-street, Leeds.*
Bellingham, Sir Alan. Castle Bellingham, Ireland.
1866. *Belper, The Right Hon. Lord, M.A., D.C.L., F.R.S., F.G.S. 75 Eaton-square, London, S.W.; and Kingston Hall, Derby.
1864. *Bendyshe, T. 7 Belgrave-villas, Margate.
1870. ‡Bennett, Alfred W., M.A., B.Sc., F.L.S. 6 Park Village East, Regent's Park, London, N.W.
1871. ‡*Bennett, F. J.* 12 *Hillmarten-road, Camden-road, London, N.*
1870. *Bennett, William. 109 Shaw-street, Liverpool.
1870. *Bennett, William, jun. Oak Hill Park, Old Swan, near Liverpool.
1852. *Bennoch, Francis, F.S.A. 5 Tavistock-square, London, W.C.
1857. ‡Benson, Charles. 11 Fitzwilliam-square West, Dublin.
Benson, Robert, jun. Fairfield, Manchester.
1848. ‡Benson, Starling, F.G.S. Gloucester-place, Swansea.
1870. ‡Benson, W. Alresford, Hants.
1863. ‡Benson, William. Fourstones Court, Newcastle-on-Tyne.
1848. ‡Bentham, George, F.R.S., F.R.G.S., F.L.S. 25 Wilton-place, Knightsbridge, London, S.W.
1842. Bentley, John. 2 Portland-place, London, W.
1863. §§Bentley, Robert, F.L.S., Professor of Botany in King's College. 1 Trebovir-road, South Kensington, London, S.W.
1875. ‡Beor, Henry R. Scientific Club, Savile-row, London, W.
1876. ‡Bergius, Walter C. 9 Loudon-terrace, Hillhead, Glasgow.
1868. ‡Berkeley, Rev. M. J., M.A., F.R.S., F.L.S. Sibbertoft, Market Harborough.
1863. ‡Berkley, C. Marley Hill, Gateshead, Durham.
1848. ‡Berrington, Arthur V. D. Woodlands Castle, near Swansea.
1870. ‡Berwick, George, M.D. 36 Fawcett-street, Sunderland.
1862. ‡Besant, William Henry, M.A., F.R.S. St. John's College, Cambridge.
1865. *Bessemer, Sir Henry, F.R.S. Denmark Hill, Camberwell, London, S.E.
1858. ‡Best, William. Leydon-terrace, Leeds.
Bethune, Admiral, C.B., F.R.G.S. Balfour, Fifeshire.
1876. *Bettany, G. T., B.A., B.Sc. Caius College, Cambridge.
1859. ‡Beveridge, Robert, M.B. 36 King-street, Aberdeen.
1874. *Bevington, James B. Merle Wood, Sevenoaks.

Year of Election.

1863. ‡Bewick, Thomas John, F.G.S. Haydon Bridge, Northumberland.
*Bickerdike, Rev. John, M.A. St. Mary's Vicarage, Leeds.
1870. ‡Bickerton, A.W., F.C.S. Hartley Institution, Southampton.
1863. ‡Bigger, Benjamin. Gateshead, Durham.
1864. ‡Biggs, Robert. 16 Green Park, Bath.
1855. ‡*Billings, Robert William.* 4 *St. Mary's-road, Canonbury, London, N.*
Bilton, Rev. William, M.A., F.G.S. United University Club, Suffolk-street, London, S.W.
1877. ‡Binder, W. J., B.A. Barnsley.
1842. Binney, Edward William, F.C.S., F.G.S. Cheetham Hill, Manchester.
1873. ‡Binns, J. Arthur. Manningham, Bradford, Yorkshire.
1879. §Binns, E. Knowles. 216 Heavygate-road, Sheffield.
Birchall, Edwin, F.L.S. Douglas, Isle of Man.
Birchall, Henry. College House, Bradford.
1866. *Birkin, Richard. Aspley Hall, near Nottingham.
*Birks, Rev. Thomas Rawson, M.A., Professor of Moral Philosophy in the University of Cambridge. 6 Salisbury-villas, Cambridge.
1841. *Birt, William Radcliff, F.R.A.S. 3 Shrewsbury-villas, Waterlane, Stratford, E.
1871. *Bischof, Gustav. 4 Hart-street, Bloomsbury, London, W.C.
1868. ‡Bishop, John. Thorpe Hamlet, Norwich.
1866. ‡Bishop, Thomas. Bramcote, Nottingham.
1877. ‡Blachford, The Right Hon. Lord, K.C.M.G. Cornwood, Ivybridge.
1869. ‡Blackall, Thomas. 13 Southernhay, Exeter.
1834. Blackburn, Bewicke. 14 Victoria-road, Kensington, London, W.
1876. ‡Blackburn, Hugh, M.A. The University, Glasgow.
Blackburne, Rev. John, M.A. Yarmouth, Isle of Wight.
Blackburne, Rev. John, jun., M.A. Rectory, Horton, near Chippenham.
1877. ‡Blackie, J. Alexander. 17 Stanhope-street, Glasgow.
1859. ‡Blackie, John Stewart, M.A., Professor of Greek in the University of Edinburgh.
1876. ‡Blackie, Robert. 7 Great Western-terrace, Glasgow.
1855. *Blackie, W. G., Ph.D., F.R.G.S. 17 Stanhope-street, Glasgow.
1870. ‡Blackmore, W. Founder's-court, Lothbury, London, E.C.
*Blackwall, Rev. John, F.L.S. Hendre House, near Llanrwst, Denbighshire.
1878. §Blair, Matthew. Oakshaw, Paisley.
1863. ‡Blake, C. Carter, D.Sc. Westminster Hospital School of Medicine, Broad Sanctuary, Westminster, S.W.
1849. *Blake, Henry Wollaston, M.A., F.R.S., F.R.G.S. 8 Devonshire place, Portland-place, London, W.
1846. *Blake, William. Bridge House, South Petherton, Somerset.
1878. §Blakeney, Rev. Canon, M.A., D.D. The Vicarage, Sheffield.
1845. ‡*Blakesley, Rev. J. W., B.D. Ware Vicarage, Hertfordshire.*
1861. §§Blakiston, Matthew, F.R.G.S. 18 Wilton-crescent, London, S.W.
Blakiston, Peyton, M.D., F.R.S. 140 Harley-street, London, W.
1868. ‡*Blanc, Henry, M.D.* 9 *Bedford-street, Bedford-square, London, W.C.*
1869. ‡Blanford, W. T., F.R.S., F.G.S., F.R.G.S., Geological Survey of India. Calcutta.
*Blomefield, Rev. Leonard, M.A., F.L.S., F.G.S. 19 Belmont, Bath.
1878. §§*Blood, T. Lloyd.*
Blore, Edward, LL.D., F.R.S., F.R.G.S., F.S.A. 4 Manchester-square, London, W.

Year of Election.

1870. ‡Blundell, Thomas Weld. Ince Blundell Hall, Great Crosby, Lancashire.
1859. ‡Blunt, Sir Charles, Bart. Heathfield Park, Sussex.
1859. ‡Blunt, Capt. Richard. Bretlands, Chertsey, Surrey.
Blyth, B. Hall. 135 George-street, Edinburgh.
1858. *Blythe, William. Holland Bank, Church, near Accrington.
1867. ‡Blyth-Martin, W. Y. Blyth House, Newport, Fife.
1870. ‡Boardman, Edward. Queen-street, Norwich.
1866. §Bogg, Thomas Wemyss. 2 East Ascent, St. Leonard's.
1876.§§Bogue, David. 192 Piccadilly, London, W.
1859. *Bohn, Henry G., F.L.S., F.R.A.S., F.R.G.S., F.S.S. North End House, Twickenham.
1871. ‡Bohn, Mrs. North End House, Twickenham.
1859. ‡Bolster, Rev. Prebendary John A. Cork.
1876. ‡Bolton, J. C. Carbrook, Stirling.
Bolton, R. L. Laurel Mount, Aigburth-road, Liverpool.
1866. ‡Bond, Banks. Low Pavement, Nottingham.
Bond, Henry John Hayes, M.D. Cambridge.
1871. §Bonney, Rev. Thomas George, M.A., F.R.S., F.S.A., F.G.S. St. John's College, Cambridge.
1866. ‡Booker, W. H. Cromwell-terrace, Nottingham.
1861. §Booth, James. Elmfield, Rochdale.
1861. *Booth, William. Hollybank, Cornbrook, Manchester.
1876. ‡Booth, William H. Trinity College, Oxford.
1861. *Borchardt, Louis, M.D. Barton Arcade, Manchester.
1849. ‡Boreham, William W., F.R.A.S. The Mount, Haverhill, Newmarket.
1876. *Borland, William. 260 West George-street, Glasgow.
1863. ‡*Borries, Theodore. Lovaine-crescent, Newcastle-on-Tyne.*
1876. *Bosanquet, R. H. M., M.A., F.C.S., F.R.S.A. St. John's College, Oxford.
*Bossey, Francis, M.D. Mayfield, Oxford-road, Redhill, Surrey.
1867. §Botly, William, F.S.A. Salisbury House, Hamlet-road, Upper Norwood, London, S.E.
1858. ‡Botterill, John. Burley, near Leeds.
1872. ‡Bottle, Alexander. Dover.
1868. ‡Bottle, J. T. 28 Nelson-road, Great Yarmouth.
1871. *Bottomley, James Thomson, M.A., F.R.S.E., F.C.S. The University, Glasgow.
Bottomley, William. 14 Brunswick-gardens, Kensington, London, W.
1876.§§Bottomley, William, jun. 14 Brunswick-gardens, Kensington. London, W.
1850. ‡Bouch, Thomas, C.E. Oxford-terrace, Edinburgh.
1870. ‡Boult, Swinton. 1 Dale-street, Liverpool.
1868. ‡Boulton, W. S. Norwich.
1866. §Bourne, Stephen, F.S.S. Abberley, Wallington, Surrey.
1872. ‡Bovill, William Edward. 29 James-street, Buckingham-gate, London, S.W.
1870. ‡Bower, Anthony. Bowersdale, Seaforth, Liverpool.
1867. ‡Bower, Dr. John. Perth.
1856. *Bowlby, Miss F. E. 23 Lansdowne-parade, Cheltenham.
1863. ‡Bowman, R. Benson. Newcastle-on-Tyne.
Bowman, William, F.R.S., F.R.C.S. 5 Clifford-street, London, W.
1869. ‡Bowring, Charles T. Elmsleigh, Prince's-park, Liverpool.
1863. ‡*Bowron, James. South Stockton-on-Tees.*

Year of Election.

1863. §§Boyd, Edward Fenwick. Moor House, near Durham.
1871. ‡Boyd, Thomas J. 41 Moray-place, Edinburgh.
1865. ‡Boyle, Rev. G. D. Soho House, Handsworth, Birmingham.
1872. *Brabrook, E. W., F.S.A., Dir. A.I. 28 Abingdon-street, Westminster, S.W.
1869. *Braby, Frederick, F.G.S., F.C.S. Cathcart House, Cathcart-road, London, S.W.
1870. ‡Brace, Edmund. 3 Spring-gardens, Kelvinside, Glasgow.
Bracebridge, Charles Holt, F.R.G.S. The Hall, Atherstone, Warwickshire.
1861. *Bradshaw, William. Slade House, Green-walk, Bowdon, Cheshire.
1842. *Brady, Sir Antonio, J.P., F.G.S. Maryland Point, Stratford, Essex, E.
1857. *Brady, Cheyne, M.R.I.A. Trinity Vicarage, West Bromwich.
Brady, Daniel F., M.D. 5 Gardiner's-row, Dublin.
1863. ‡Brady, George S., M.D., F.L.S., Professor of Natural History in the College of Physical Science, Newcastle-on-Tyne. 22 Fawcett-street, Sunderland.
1862. §§Brady, Henry Bowman, F.R.S., F.L.S., F.G.S. Hillfield, Gateshead.
1875. ‡Bragge, William, F.S.A., F.G.S. Shirle Hill, Sheffield.
1864. §Braham, Philip, F.C.S. 6 George-street, Bath.
1870. §§Braidwood, Dr. Delemere-terrace, Birkenhead.
1864. §Braikenridge, Rev. George Weare, M.A., F.L.S. Clevedon, Somerset.
1879. §Bramley, Herbert. Claremont-crescent, Sheffield.
1865. §Bramwell, Frederick J., M.I.C.E., F.R.S. 37 Great George-street, London, S.W.
1872. ‡Bramwell, William J. 17 Prince Albert-street, Brighton.
1867. ‡Brand, William. Milnefield, Dundee.
1861. *Brandreth, Rev. Henry. Dickleburgh Rectory, Scole, Norfolk.
1852. ‡Brazier, James S., F.C.S., Professor of Chemistry in Marischal College and University of Aberdeen.
1857. ‡Brazill, Thomas. 12 Holles-street, Dublin.
1869. *Breadalbane, The Right Hon. the Earl of. Taymouth Castle, N.B.; and Carlton Club, Pall Mall, London, S.W.
1873. ‡Breffit, Edgar. Castleford, near Normanton.
1868. ‡Bremridge, Elias. 17 Bloomsbury-square, London, W.C.
1877. ‡Brent, Francis. 19 Clarendon-place, Plymouth.
1860. ‡Brett, G. Salford.
1866. ‡Brettell, Thomas (Mine Agent). Dudley.
1875. §§Briant, T. Hampton Wick, Kingston-on-Thames.
1867. ‡Bridgman, William Kenceley. 69 St. Giles's-street, Norwich.
1870. *Bridson, Joseph R. Belle Isle, Windermere.
1870. ‡Brierley, Joseph, C.E. New Market-street, Blackburn.
1879. §Brierley, Morgan. Denshaw House, Saddleworth.
1870. *Brigg, John. Broomfield, Keighley, Yorkshire.
1866. *Briggs, Arthur. Cragg Royd, Rawdon, near Leeds.
1866. ‡Briggs, Joseph. Barrow-in-Furness.
1863. *Bright, Sir Charles Tilston, C.E., F.G.S., F.R.G.S., F.R.A.S. 20 Bolton-gardens, London, S.W.
1870. ‡Bright, H. A., M.A., F.R.G.S. Ashfield, Knotty Ash.
Bright, The Right Hon. John, M.P. Rochdale, Lancashire.
1868. ‡*Brine, Commander Lindesay. Army and Navy Club, Pall Mall, London, S.W.*
1879. §Brittain, Frederick. Taptonville-crescent, Sheffield.
1879. *Brittain, W. H. Storth Oaks, Ranmoor, Sheffield.
1878. §§Britten, James, F.L.S. Department of Botany, British Museum, London, W.C.

Year of Election.

1842. *Broadbent, Thomas. Marsden-square, Manchester.*
1859. *Brodhurst, Bernard Edward, F.R.C.S., F.L.S. 20 Grosvenor-street, Grosvenor-square, London, W.
1847. ‡Brodie, Sir Benjamin C., Bart., M.A., D.C.L., F.R.S., F.C.S. Brockham Warren, Reigate.
1834. ‡Brodie, Rev. James, F.G.S. Monimail, Fifeshire.
1865. ‡Brodie, Rev. Peter Bellenger, M.A., F.G.S. Rowington Vicarage, near Warwick.
1853. ‡Bromby, J. H., M.A. The Charter House, Hull.
1878. *Brook, George, F.L.S. Huddersfield, Yorkshire.
1855. ‡Brooke, Edward. Marsden House, Stockport, Cheshire.
1864. *Brooke, Rev. J. Ingham. Thornhill Rectory, Dewsbury.
1855. ‡Brooke, Peter William. Marsden House, Stockport, Cheshire.
1878. §§Brooke, Sir Victor, Bart., F.L.S. Colebrook, Brookeborough, Co. Fermanagh.
1863. §§Brooks, John Crosse. Wallsend, Newcastle-on-Tyne.
1846. *Brooks, Thomas. Cranshaw Hall, Rawtenstall, Manchester.
Brooks, William. Ordfall Hill, East Retford, Nottinghamshire.
1874. ‡Broom, William. 20 Woodlands-terrace, Glasgow.
1847. ‡Broome, C. Edward, F.L.S. Elmhurst, Batheaston, near Bath.
*Broun, John Allan, F.R.S. 9 Abercorn-place, St. John's Wood, London, N.W.
1863. *Brown, Alexander Crum, M.D., F.R.S. L. & E., F.C.S., Professor of Chemistry in the University of Edinburgh. 8 Belgrave-crescent, Edinburgh.
1867. ‡Brown, Charles Gage, M.D. 88 Sloane-street, London, S.W.
1855. ‡Brown, Colin. 192 Hope-street, Glasgow.
1871. §§Brown, David. 93 Abbey-hill, Edinburgh.
1863. *Brown, Rev. Dixon. Unthank Hall, Haltwhistle, Carlisle.
1870. §Brown, Horace T. The Bank, Burton-on-Trent.
Brown, Hugh. Broadstone, Ayrshire.
1870. *Brown, J. Campbell, D.Sc., F.C.S. Royal Infirmary School of Medicine, Liverpool.
1876. ‡Brown, John. Edenderry House, Belfast.
1859. ‡Brown, Rev. John Crombie, LL.D., F.L.S. Berwick-on-Tweed.
1874. ‡Brown, John S. Edenderry, Shaw's Bridge, Belfast.
1863. ‡Brown, Ralph. Lambton's Bank, Newcastle-on-Tyne.
1871. ‡Brown, Robert, M.A., Ph.D., F.L.S., F.R.G.S. 26 Guildford-road, Albert-square, London, S.W.
1868. ‡Brown, Samuel. Grafton House, Swindon, Wilts.
*Brown, Thomas. Evesham Lawn, Pittville, Cheltenham.
*Brown, William. 11 Maiden-terrace, Dartmouth Park, London, N.
1855. ‡Brown, William. 33 Berkeley-terrace, Glasgow.
1850. ‡Brown, William, F.R.S.E. 25 Dublin-street, Edinburgh.
1865. ‡Brown, William. 41A New-street, Birmingham.
1879. §Browne, J. Crichton, M.D., LL.D., F.R.S.E. 7 Cumberland-terrace, Regent's Park, London, N.W.
1866. *Browne, Rev. J. H. Lowdham Vicarage, Nottingham.
1862. *Browne, Robert Clayton, jun., B.A. Browne's Hill, Carlow, Ireland.
1872. ‡Browne, R. Mackley, F.G.S. Northside, St. John's, Sevenoaks, Kent.
1875. ‡Browne, Walter R. Bridgwater.
1865. *Browne, William, M.D. The Friary, Lichfield.
1865. ‡Browning, John, F.R.A.S. 111 Minories, London, E.
1855. ‡Brownlee, James, jun. 30 Burnbank-gardens, Glasgow.
1853. ‡*Brownlow, William B. Villa-place, Hull.*

Year of Election.

1863. *Brunel, H. M. 23 Delahay-street, Westminster, S.W.
1863. ‡Brunel, J. 23 Delahay-street, Westminster, S.W.
1875. *Brunlees, James, C.E., F.G.S. 5 Victoria-street, Westminster, S.W.
1875. ‡Brunlees, John. 5 Victoria-street, Westminster, S.W.
1868. ‡Brunton, T. Lauder, M.D., F.R.S. 50 Welbeck-street, London, W.
1878. §§Brutton, Joseph. Yeovil.
1877. ‡Bryant, George. 82 Claverton-street, Pimlico, London, S.W.
1875. ‡Bryant, G. Squier. 15 White Ladies'-road, Clifton, Bristol.
1875. †Bryant, Miss S. A. The Castle, Denbigh.
1861. ‡Bryce, James. York-place, Higher Broughton, Manchester.
Bryce, Rev. R. J., LL.D., Principal of Belfast Academy. Belfast.
1859. ‡Bryson, William Gillespie. Cullen, Aberdeen.
1867. ‡Buccleuch and Queensberry, His Grace the Duke of, K.G., D.C.L., F.R.S. L. & E., F.L.S. Whitehall-gardens, London, S.W.; and Dalkeith House, Edinburgh.
1871. §Buchan, Alexander, M.A., F.R.S.E., Sec. Scottish Meteorological Society. 72 Northumberland-street, Edinburgh.
1867. ‡Buchan, Thomas. Strawberry Bank, Dundee.
Buchanan, Andrew, M.D., Professor of the Institutes of Medicine in the University of Glasgow. 4 Ethol-place, Glasgow.
Buchanan, Archibald. Catrine, Ayrshire.
Buchanan, D. C. Poulton-cum-Seacombe, Cheshire.
1871. ‡Buchanan, John Young. 10 Moray-place, Edinburgh.
1864. §Buckle, Rev. George, M.A. The Rectory, Weston-super-Mare.
1865. *Buckley, Henry. 27 Wheeley's-road, Edgbaston, Birmingham.
1848. *Buckman, Professor James, F.L.S., F.G.S. Bradford Abbas, Sherborne, Dorsetshire.
1869. ‡Bucknill, J. C., M.D., F.R.S. 39 Wimpole-street, London, W.
1851. *Buckton, George Bowdler, F.R.S., F.L.S., F.C.S. Weycombe, Haslemere, Surrey.
1848. *Budd, James Palmer. Ystalyfera Iron Works, Swansea.
1875. §§Budgett, Samuel. Cotham House, Bristol.
1871. §§Bulloch, Matthew. 11 Park-circus, Glasgow.
1845. *Bunbury, Sir Charles James Fox, Bart., F.R.S., F.L.S., F.G.S., F.R.G.S. Barton Hall, Bury St. Edmunds.
1865. ‡Bunce, John Mackray. 'Journal' Office, New-street, Birmingham.
1863. §Bunning, T. Wood. Institute of Mining and Mechanical Engineers, Newcastle-on-Tyne.
1842. *Burd, John. 5 Gower-street, London, W.C.
1875. ‡Burder, John, M.D. 7 South-parade, Bristol.
1869. ‡Burdett-Coutts, Baroness. Stratton-street, Piccadilly, London, W.
1874. ‡Burdon, Henry, M.D. Clandeboye, Belfast.
1872. *Burgess, Herbert. 62 High-street, Battle, Sussex.
1876. ‡Burnet, John. 14 Victoria-crescent, Dowanhill, Glasgow.
1859. ‡Burnett, Newell. Belmont-street, Aberdeen.
1877. ‡Burns, David, C.E. Alston, Carlisle.
1860. ‡Burrows, Montague, M.A., Professor of Modern History, Oxford.
1877. ‡Burt, J. Kendall. Kendal.
1874. ‡Burt, Rev. J. T. Broadmoor, Berks.
1866. *Burton, Frederick M., F.G.S. Highfield, Gainsborough.
1879. §Bury, Percy B. Cambridge.
1864. ‡Bush, W. 7 Circus, Bath.
Bushell, Christopher. Royal Assurance-buildings, Liverpool.

Year of Election.

1855. *Busk, George, F.R.S., V.P.L.S., F.G.S. 52 Harley-street, Cavendish-square, London, W.
1878. §§Butcher, J. G., M.A. 22 Collingham-place, London, S.W.
1872. ‡Buxton, Charles Louis. Cromer, Norfolk.
1870. ‡Buxton, David, Ph.D. 1 Nottingham-place, London, W.
1868. ‡Buxton, S. Gurney. Catton Hall, Norwich.
1872. ‡Buxton, Sir T. Fowell, Bart. Warlies, Waltham Abbey, Essex.
1854. ‡Byerley, Isaac, F.L.S. Seacombe, Liverpool.
Byng, William Bateman. 2 Bank-street, Ipswich.
1852. ‡Byrne, Very Rev. James. Ergenagh Rectory, Omagh.
1875. §Byrom, W. Ascroft, F.G.S. 27 King-street, Wigan.

1858. §Cail, John. Stokesley, Yorkshire.
1863. ‡Cail, Richard. Beaconsfield, Gateshead.
1858. *Caine, Rev. William, M.A. Christ Church Rectory, Denton, near Manchester.
1876. §§Caird, Alexander M'Neel. Genoch, Wigtownshire.
1863. ‡Caird, Edward. Finnart, Dumbartonshire.
1876. ‡Caird, Edward B. 8 Scotland-street, Glasgow.
1861. *Caird, James Key. 8 Magdalene-road, Dundee.
1855. *Caird, James Tennant. Belleaire, Greenock.
1875. ‡Caldicott, Rev. J. W., D.D. The Grammar School, Bristol.
1877. ‡Caldwell, Miss. 2 Victoria-terrace, Portobello, Edinburgh.
1868. ‡Caley, A. J. Norwich.
1868. ‡Caley, W. Norwich.
1857. ‡Callan, Rev. N. J., Professor of Natural Philosophy in Maynooth College.
1853. ‡Calver, Captain E. K., R.N., F.R.S. The Grange, Redhill, Surrey.
1876. ‡Cameron, Charles, M.D., LL.D., M.P. 1 Huntly-gardens, Glasgow.
1857. ‡Cameron, Charles A., M.D. 15 Pembroke-road, Dublin.
1870. ‡Cameron, John, M.D. 17 Rodney-street, Liverpool.
1857. *Campbell, Dugald, F.C.S. 7 Quality-court, Chancery-lane, London, W.C.
1874. *Campbell, Sir George, K.C.S.I., M.P., D.C.L., F.R.G.S. 13 Cornwall-gardens, South Kensington, London, S.W.; and Edenwood, Cupar, Fife.
Campbell, Sir Hugh P. H., Bart. 10 Hill-street, Berkeley-square, London, W.; and Marchmont House, near Dunse, Berwickshire.
1876. ‡Campbell, James A. 3 Claremont-terrace, Glasgow.
Campbell, John Archibald, M.D., F.R.S.E. Albyn-place, Edinburgh.
1872. ‡Campbell, Rev. J. R., D.D. 5 Eldon-place, Manningham-lane, Bradford, Yorkshire.
1859. ‡Campbell, William. Dunmore, Argyllshire.
1871. ‡Campbell, William Hunter, LL.D. Georgetown, Demerara, British Guiana. (Messrs. Ridgway & Sons, 2 Waterloo-place, London, S.W.)
Campbell-Johnston, Alexander Robert, F.R.S. 84 St. George's-square, London, S.W.
1876. §Campion, Frank, F.G.S., F.R.G.S. The Mount, Duffield-road, Derby.
1862. *Campion, Rev. Dr. William M. Queen's College, Cambridge.
1868. *Cann, William. 9 Southernhay, Exeter.
1873. *Carbutt, Edward Hamer, C.E. St. Ann's, Burley, Leeds, Yorkshire.
*Carew, William Henry Pole. Antony, Torpoint, Devonport.
1877. ‡Carkeet, John, C.E. 3 St. Andrew's-place, Plymouth.
1876. ‡Carlile, Thomas. 5 St. James's-terrace, Glasgow.
Carlisle, The Right Rev. Harvey Goodwin, D.D., Lord Bishop of. Carlisle.

Year of Election.

1861. ‡Carlton, James. Mosley-street, Manchester.
1867. ‡Carmichael, David (Engineer). Dundee.
1867. ‡Carmichael, George. 11 Dudhope-terrace, Dundee.
Carmichael, John T. C. Messrs. Todd & Co., Cork.
1876. ‡Carmichael, Neil, M.D. 22 South Cumberland-street, Glasgow.
1871. ‡Carpenter, Charles. Brunswick-square, Brighton.
1871. *Carpenter, P. Herbert, M.A. Eton College, Windsor.
1854. ‡Carpenter, Rev. R. Lant, B.A. Bridport.
1845. ‡Carpenter, William B., C.B., M.D., LL.D., F.R.S., F.L.S., F.G.S., Registrar of the University of London. 56 Regent's Park-road, London, N.W.
1872. §Carpenter, William Lant, B.A., B.Sc., F.C.S. Winifred House, Pembroke-road, Clifton, Bristol.
1842. *Carr, William, M.D., F.L.S., F.R.C.S. Lee Grove, Blackheath, London, S.E.
1867. §§Carruthers, William, F.R.S., F.L.S., F.G.S. British Museum, London, W.C.
1861. *Carson, Rev. Joseph, D.D., M.R.I.A. 18 Fitzwilliam-place, Dublin.
1857. ‡Carte, Alexander, M.D. Royal Dublin Society, Dublin.
1868. ‡Carteighe, Michael, F.C.S. 172 New Bond-street, London, W.
1866. ‡Carter, H. H. The Park, Nottingham.
1855. ‡Carter, Richard, C.E., F.G.S. Cockerham Hall, Barnsley, Yorkshire.
1870. ‡Carter, Dr. William. 62 Elizabeth-street, Liverpool.
*Cartmell, Rev. James, D.D., F.G.S., Master of Christ's College. Christ College Lodge, Cambridge.
1878. §Cartwright, H. S., LL.B. Magherafelt Manor, Co. Derry.
1870. §§Cartwright, Joshua, A.I.C.E., Borough Surveyor. Bury, Lancashire.
1862. ‡Carulla, Facundo, F.A.S.L. Care of Messrs. Daglish and Co., 8 Harrington-street, Liverpool.
1868. ‡Cary, Joseph Henry. Newmarket-road, Norwich.
1866. ‡Casella, L. P., F.R.A.S. 147 Holborn Bars, London, E.C.
1878. §§Casey, John, LL.D., F.R.S., M.R.I.A., Professor of Higher Mathematics in the Catholic University of Ireland. 2 Iona-terrace, South Circular-road, Dublin.
1871. ‡Cash, Joseph. Bird-grove, Coventry.
1873. *Cash, William, F.G.S. 38 Elmfield-terrace, Saville Park, Halifax.
Castle, Charles. Clifton, Bristol.
1874. ‡Caton, Richard, M.D., Lecturer on Physiology at the Liverpool Medical School. 18A Abercromby-square, Liverpool.
1853. ‡Cator, John B., Commander R.N. 1 Adelaide-street, Hull.
1859. ‡Catto, Robert. 44 King-street, Aberdeen.
1873. *Cavendish, Lord Frederick, M.P. 21 Carlton House-terrace, London, S.W.
1849. ‡Cawley, Charles Edward. The Heath, Kirsall, Manchester.
1860. §§Cayley, Arthur, LL.D., F.R.S., V.P.R.A.S., Sadlerian Professor of Mathemathics in the University of Cambridge. Garden House, Cambridge.
Cayley, Digby. Brompton, near Scarborough.
Cayley, Edward Stillingfleet. Wydale, Malton, Yorkshire.
1871. *Cecil, Lord Sackville. Hayes Common, Beckenham, Kent.
1879. §Chadburn, Alfred. Brincliffe Rise, Sheffield.
1870. ‡Chadburn, C. H. Lord-street, Liverpool.
1858. *Chadwick, Charles, M.D. Lynncourt, Broadwater Down, Tunbridge Wells.
1860. ‡Chadwick, David, M.P. The Poplars, Herne Hill, London, S.E.
1842. Chadwick, Edwin, C.B. Richmond, Surrey.
1859. ‡Chadwick, Robert. Highbank, Manchester.

Year of Election.

1861. ‡Chadwick, Thomas. Wilmslow Grange, Cheshire.
*Challis, Rev. James, M.A., F.R.S., F.R.A.S., Plumian Professor of Astronomy in the University of Cambridge. 2 Trumpington-street, Cambridge.
1859. ‡Chalmers, John Inglis. Aldbar, Aberdeen.
1865. ‡Chamberlain, J. H. Christ Church-buildings, Birmingham.
1868. ‡*Chamberlain, Robert. Catton, Norwich.*
1842. Chambers, George. High Green, Sheffield.
1868. ‡Chambers, W. O. Lowestoft, Suffolk.
1877. *Champernowne, Arthur, M.A., F.G.S. Dartington Hall, Totnes, Devon.
*Champney, Henry Nelson. 4 New-street, York.
1865. ‡Chance, A. M. Edgbaston, Birmingham.
1865. *Chance, James T. Four Oaks Park, Sutton Coldfield, Birmingham.
1865.§§Chance, Robert Lucas. Chad Hill, Edgbaston, Birmingham.
1861. *Chapman, Edward, M.A., F.L.S., F.C.S. Frewen Hall, Oxford.
1877.§§Chapman, T. Algernon, M.D. Burghill, Hereford.
1866. ‡Chapman, William. The Park, Nottingham.
1871. §Chappell, William, F.S.A. Strafford Lodge, Oatlands Park, Weybridge Station.
1874. ‡Charles, John James, M.A., M.D. 11 Fisherwick-place, Belfast.
1871. ‡*Charles, T. C., M.D. Queen's College, Belfast.*
1836. Charlesworth, Edward, F.G.S. 277 Strand, London, W.C.
1874. ‡Charley, William. Seymour Hill, Dunmurry, Ireland.
1863. ‡Charlton, Edward, M.D. 7 Eldon-square, Newcastle-on-Tyne.
1866. ‡Charnock, Richard Stephen, Ph.D., F.S.A., F.R.G.S. Junior Garrick Club, Adelphi-terrace, London, W.C.
Chatto, W. J. P. Union Club, Trafalgar-square, London, S.W.
1867. *Chatwood, Samuel. 5 Wentworth-place, Bolton.
1864. ‡Cheadle, W. B., M.A., M.D., F.R.G.S. 2 Hyde Park-place, Cumberland-gate, London, S.W.
1874. *Chermside, Lieutenant H. C., R.E. Care of Messrs. Cox & Co., Craig's-court, Charing Cross, London, S.W.
1879. *Chesterman, W. Broomsgrove-road, Sheffield.
1879. §Cheyne, Commander J. P., R.N. 1 Westgate-terrace, West Brompton, London, S.W.
1872.§§Chichester, The Right Hon. the Earl of. Stanmer House, Lewes.
Chichester, The Right Rev. Richard Durnford, D.D., Lord Bishop of. Chichester.
1865. *Child, Gilbert W., M.A., M.D., F.L.S. Cowley House, Oxford.
1842. *Chiswell, Thomas. 17 Lincoln-grove, Plymouth-grove, Manchester.
1863. ‡Cholmeley, Rev. C. H. Dinton Rectory, Salisbury.
1859. ‡Christie, John, M.D. 46 School-hill, Aberdeen.
1861. ‡Christie, Professor R. C., M.A. 7 St. James's-square, Manchester.
Christison, Sir Robert, Bart., M.D., D.C.L., F.R.S.E., Professor of Dietetics, Materia Medica, and Pharmacy in the University of Edinburgh. Edinburgh.
1875. *Christopher, George, F.C.S. 8 Rectory-grove, Clapham, London, S.W.
1876. *Chrystal, G., B.A., Professor of Mathematics. The University, St. Andrews, N.B.
1870.§§Church, A. H., F.C.S., Professor of Chemistry in the Royal Agricultural College, Cirencester.
1860. ‡Church, William Selby, M.A. St. Bartholomew's Hospital, London, E.C.
1857. ‡Churchill, F., M.D. Ardtrea Rectory, Stewartstown, Co. Tyrone.
1868. ‡Clabburn, W. H. Thorpe, Norwich.

Year of Election.

1863. ‡*Clapham, A.* 3 *Oxford-street, Newcastle-on-Tyne.*
1863. ‡Clapham, Henry. 5 Summerhill-grove, Newcastle-on-Tyne.
1855. §§Clapham, Robert Calvert. Earsdon House, Earsdon, Newcastle-on-Tyne.
1869. §§Clapp, Frederick. 44 Magdalen-street, Exeter.
1857. ‡Clarendon, Frederick Villiers. 1 Belvidere-place, Mountjoy-square, Dublin.
1859. ‡Clark, David. Coupar Angus, Fifeshire.
1876. ‡*Clark, David P. Glasgow.*
1877. *Clark, F. J. 20 Bootham, York.
Clark, G. T. Bombay; and Athenæum Club, London, S.W.
1876. ‡Clark, George W. Glasgow.
1876. ‡Clark, Dr. John. 138 Bath-street, Glasgow.
1861. ‡Clark, Latimer. 5 Westminster-chambers, Victoria-street, London, S.W.
1855. ‡Clark, Rev. William, M.A. Barrhead, near Glasgow.
1865. ‡Clarke, Rev. Charles. Charlotte-road, Edgbaston, Birmingham.
1875. ‡Clarke, Charles S. 4 Worcester-terrace, Clifton, Bristol.
Clarke, George. Mosley-street, Manchester.
1872. *Clarke, Hyde. 32 St. George's-square, Pimlico, London, S.W.
1875. ‡Clarke, John Henry. 4 Worcester-terrace, Clifton, Bristol.
1861. *Clarke, John Hope. Lark Hill House, Edgeley, Stockport.
1877. ‡Clarke, Professor John W. University of Chicago, Illinois.
1851. ‡Clarke, Joshua, F.L.S. Fairycroft, Saffron Walden.
Clarke, Thomas, M.A. Knedlington Manor, Howden, Yorkshire.
1861. ‡Clay, Charles, M.D. 101 Piccadilly, Manchester.
*Clay, Joseph Travis, F.G.S. Rastrick, near Brighouse, Yorkshire.
1856. *Clay, Colonel William. The Slopes, Wallasea, Cheshire.
1866. ‡Clayden, P. W. 13 Tavistock-square, London, W.C.
1850. ‡Cleghorn, Hugh, M.D., F.L.S., late Conservator of Forests, Madras. Stravithie, St. Andrews, Scotland.
1859. ‡Cleghorn, John. Wick.
1875. ‡Clegram, T. W. B. Saul Lodge, near Stonehouse, Gloucestershire.
1861. §§Cleland, John, M.D., F.R.S., Professor of Anatomy in the University of Glasgow. 2 College, Glasgow.
1857. ‡Clements, Henry. Dromin, Listowel, Ireland.
‡Clerk, Rev. D. M. Deverill, Warminster, Wiltshire.
1852. ‡Clibborn, Edward. Royal Irish Academy, Dublin.
1873. §Cliff, John, F.G.S. Halton, Runcorn.
1861. *Clifton, R. Bellamy, M.A., F.R.S., F.R.A.S., Professor of Experimental Philosophy in the University of Oxford. Portland Lodge, Park Town, Oxford.
Clonbrock, Lord Robert. Clonbrock, Galway.
1854. ‡Close, The Very Rev. Francis, M.A. Carlisle.
1878. §§Close, Rev. Maxwell H., F.G.S. 40 Lower Baggot-street, Dublin.
1866. §Close, Thomas, F.S.A. St. James's-street, Nottingham.
1873. ‡Clough, John. Bracken Bank, Keighley, Yorkshire.
1859. ‡Clouston, Rev. Charles. Sandwick, Orkney.
1861. *Clouston, Peter. 1 Park Terrace, Glasgow.
1863. *Clutterbuck, Thomas. Warkworth, Acklington.
1868. ‡Coaks, J. B. Thorpe, Norwich.
1855. *Coats, Sir Peter. Woodside, Paisley.
1855. *Coats, Thomas. Fergeslie House, Paisley.
Cobb, Edward. 13 Great Bedford-street, Bath.
1851. *Cobbold, John Chevallier. Holywells, Ipswich; and Athenæum Club, London, S.W.

Year of Election.

1864. ‡Cobbold, T. Spencer, M.D., F.R.S., F.L.S., Professor of Botany and Helminthology in the Royal Veterinary College, London. 74 Portsdown-road, Maida Hill, London, W.
1864. *Cochrane, James Henry. Monmouth House, Wellington-terrace, Clevedon, Somersetshire.
1861. *Coe, Rev. Charles C., F.R.G.S. Highfield, Manchester-road, Bolton.
1865. ‡Coghill, H. Newcastle-under-Lyme.
1876. ‡Colbourn, E. Rushton. 5 Marchmont-terrace, Hillhead, Glasgow.
1853. ‡Colchester, William, F.G.S. Springfield House, Ipswich.
1868. ‡Colchester, W. P. Bassingbourn, Royston.
1879. §Cole, Skelton. 387 Glossop-road, Sheffield.
1876. §§Colebrooke, Sir T. E., Bart., M.P., F.R.G.S. 14 South-street, Park-lane, London, W.; and Abington House, Abington, N.B.
1860. ‡Coleman, J. J., F.C.S. 69 St. George's-place, Glasgow.
1878. §Coles, John, Curator of the Map Collection R.G.S. 1 Savile-row, London, W.
1854. *Colfox, William, B.A. Westmead, Bridport, Dorsetshire.
1857. ‡Colles, William, M.D. 21 Stephen's-green, Dublin.
1869. ‡Collier, W. F. Woodtown, Horrabridge, South Devon.
1854. ‡Collingwood, Cuthbert, M.A., M.B., F.L.S. 4 Grove-terrace, Belvedere-road, Upper Norwood, Surrey, S.E.
1861. *Collingwood, J. Frederick, F.G.S. Anthropological Institute, 4 St. Martin's-place, London, W.C.
1865. *Collins, James Tertius. Churchfield, Edgbaston, Birmingham.
1876. §Collins, J. H., F.G.S. 57 Lemon-street, Truro, Cornwall.
1876. ‡Collins, William. 3 Park-terrace East, Glasgow.
Collis, Stephen Edward. Listowel, Ireland.
1868. *Colman, J. J., M.P. Carrow House, Norwich; and 108 Cannon-street, London, E.C.
1870. ‡Coltart, Robert. The Hollies, Aigburth-road, Liverpool.
Colthurst, John. Clifton, Bristol.
1874. ‡Combe, James. Ormiston House, Belfast.
*Compton, The Ven. Lord Alwyn. Castle Ashby, Northamptonshire; and 145 Piccadilly, London, W.
1846. *Compton, Lord William. 145 Piccadilly, London, W.
1852. ‡Connal, Michael. 16 Lynedock-terrace, Glasgow.
1871. *Connor, Charles C. Hope House, College Park East, Belfast.
1876. ‡Cook, James. 162 North-street, Glasgow.
1876. *Cooke, Conrad W., C.E. 5 Westminster Chambers, London, S.W.
1863. ‡Cooke, Edward William, R.A., F.R.S., F.R.G.S., F.L.S., F.G.S. Glen Andred, Groombridge, Sussex; and Athenæum Club, Pall Mall, London, S.W.
1868. ‡Cooke, Rev. George H. Wanstead Vicarage, near Norwich.
Cooke, James R., M.A. 73 Blessington-street, Dublin.
Cooke, J. B. Cavendish-road, Birkenhead.
1868. ‡Cooke, M. C., M.A. 2 Grosvenor-villas, Upper Holloway, London, N.
1878. §§Cooke, Samuel, M.A., F.G.S. Poona, Bombay.
Cooke, Rev. T. L., M.A. Magdalen College, Oxford.
1859. *Cooke, William Henry, M.A., Q.C., F.S.A. 42 Wimpole-street, London, W.; and Rainthorpe Hall, Long Stratton.
1865. ‡Cooksey, Joseph. West Bromwich, Birmingham.
1863. ‡Cookson, N. C. Benwell Tower, Newcastle-on-Tyne.
1869. §Cooling, Edwin, F.R.G.S. Mile Ash, Derby.
1850. ‡Cooper, Sir Henry, M.D. 7 Charlotte-street, Hull.
Cooper, James. 58 Pembridge-villas, Bayswater, London, W.

Year of Election.

1879. §Cooper, Thomas. Rose Hill, Rotherham, Yorkshire.
1875. ‡Cooper, T. T., F.R.G.S. Care of Messrs. King & Co., Cornhill, London, E.C.
1868. ‡Cooper, W. J. The Old Palace, Richmond, Surrey.
1846. ‡Cooper, William White, F.R.C.S. 19 Berkeley-square, London, W.
1878.§§Cope, Rev. S. W. Bramley, Leeds.
1871. ‡*Copeland, Ralph, Ph.D. Parsonstown, Ireland.*
1868. ‡Copeman, Edward, M.D. Upper King-street, Norwich.
1863. ‡Coppin, John. North Shields.
1842. Corbett, Edward. Ravenoak, Cheadle-hulme, Cheshire.
1855. ‡Corbett, Joseph Henry, M.D., Professor of Anatomy and Physiology in Queen's College, Cork.
1870. *Corfield, W. H., M.A., M.D., F.G.S., Professor of Hygiène and Public Health in University College. 10 Bolton-row, Mayfair, London, W.
Cory, Rev. Robert, B.D., F.C.P.S. Stanground, Peterborough.
Cottam, George. 2 Winsley-street, London, W.
1857. ‡Cottam, Samuel. Brazenose-street, Manchester.
1855. ‡Cotterill, Rev. Henry, Bishop of Edinburgh. Edinburgh.
1874. *Cotterill, J. H., M.A., F.R.S., Professor of Applied Mechanics. Royal Naval College, Greenwich, S.E.
1879. §Cottrill, Gilbert I. Shepton Mallett, Somerset.
1864. ‡Cotton, General Frederick C., R.E., C.S.I. 13 Longridge-road, Earl's Court-road, London, S.W.
1869. ‡Cotton, William. Pennsylvania, Exeter.
*Cotton, Rev. William Charles, M.A. Vicarage, Frodsham, Cheshire.
1876. ‡Couper, James. City Glass Works, Glasgow.
1876. ‡Couper, James, jun. City Glass Works, Glasgow.
1874. ‡Courtauld, John M. Bocking Bridge, Braintree, Essex.
1865. ‡Courtauld, Samuel, F.R.A.S. 76 Lancaster-gate, London, W.; and Gosfield Hall, Essex.
1834. ‡Cowan, Charles. 38 West Register-street, Edinburgh.
1876. ‡Cowan, J. B. 159 Bath-street, Glasgow.
Cowan, John. Valleyfield, Pennycuick, Edinburgh.
1863. ‡Cowan, John A. Blaydon Burn, Durham.
1863. ‡Cowan, Joseph, jun. Blaydon, Durham.
1872. *Cowan, Thomas William. Comptons Lea, Horsham.
1873. **Cowans, John. Cranford, Middlesex.*
Cowie, The Very Rev. Benjamin Morgan, M.A., B.D., Dean of Manchester. The Deanery, Manchester.
1871. ‡Cowper, C. E. 3 Great George-street, Westminster, S.W.
1860. ‡Cowper, Edward Alfred, M.I.C.E. 6 Great George-street, Westminster, S.W.
1867. *Cox, Edward. 18 Windsor-street, Dundee.
1867. *Cox, George Addison. Beechwood, Dundee.
1867. ‡Cox, James. Clement Park, Lochee, Dundee.
1870. *Cox, James. 8 Falkner-square, Liverpool.
1867. *Cox, Thomas Hunter. Duncarse, Dundee.
1867. ‡Cox, William. Foggley, Lochee, by Dundee.
1866. *Cox, William H. 50 Newhall-street, Birmingham.
1871. ‡*Cox, William J. 2 Vanburgh-place, Leith.*
Craig, J. T. Gibson, F.R.S.E. 24 York-place, Edinburgh.
1859. ‡*Craig, S. The Wallands, Lewes, Sussex.*
1876. ‡Cramb, John. Larch Villa, Helensburgh, N.B.
1857. ‡Crampton, Rev. Josiah. The Rectory, Florence Court, Co. Fermanagh, Ireland.
1879. §Crampton, Thomas Russell. 13 Victoria-street, London, S.W.

Year of Election.

1858. ‡Cranage, Edward, Ph.D. The Old Hall, Wellington, Shropshire.
1876. ‡Crawford, Chalmond, M.P. Ridemon, Crosscar.
1871. *Crawford, William Caldwell, M.A. Hobart House, Eskbank, near Edinburgh.
1871. ‡Crawshaw, Edward. Burnley, Lancashire.
1870. *Crawshay, Mrs. Robert. Cyfarthfa Castle, Merthyr Tydvil.
1879. §Creswick, Nathaniel. Handsworth Grange, near Sheffield.
1876. *Crewdson, Rev. George. St. George's Vicarage, Kendal.
Creyke, The Venerable Archdeacon. Bolton Percy Rectory, Tadcaster.
1858. ‡Crofts, John. Hillary-place, Leeds.
1878. §Croke, John O'Byrne, M.A. The French College, Blackrock; and 79 Strand-road, Sandymount, Dublin.
1859. ‡Croll, A. A. 10 Coleman-street, London, E.C.
1857. ‡Crolly, Rev. George. Maynooth College, Ireland.
1866. ‡Cronin, William. 4 Brunel-terrace, Nottingham.
1870. ‡Crookes, Joseph. Marlborough House, Brook Green, Hammersmith, London, W.
1865. §Crookes, William, F.R.S., F.C.S. 20 Mornington-road, Regent's Park, London, N.W.
1879. §Crookes, Mrs. 20 Mornington-road, Regent's Park, London, N.W.
1855. ‡Cropper, Rev. John. Wareham, Dorsetshire.
1870. ‡Crosfield, C. J. 16 Alexandra-drive, Prince's Park, Liverpool.
1870. ‡Crosfield, William, sen. Annesley, Aigburth, Liverpool.
1870. *Crosfield, William, jun. 16 Alexandra-drive, Prince's Park, Liverpool.
1861. ‡Cross, Rev. John Edward, M.A. Appleby Vicarage, near Brigg.
1868. ‡Crosse, Thomas William. St. Giles's-street, Norwich.
1867. §§Crosskey, Rev. H. W., F.G.S. 28 George-road, Edgbaston, Birmingham.
1853. ‡Crosskill, William, C.E. Beverley, Yorkshire.
1870. *Crossley, Edward, F.R.A.S. Bemerside, Halifax.
1871. ‡Crossley, Herbert. Broomfield, Halifax.
1866. *Crossley, Louis J., F.M.S. Moorside Observatory, near Halifax.
1861. §§Crowley, Henry. Trafalgar-road, Birkdale Park, Southport.
1863. ‡Cruddas, George. Elswick Engine Works, Newcastle-on-Tyne.
1860. ‡Cruickshank, John. City of Glasgow Bank, Aberdeen.
1859. ‡Cruickshank, Provost. Macduff, Aberdeen.
1873. ‡Crust, Walter. Hall-street, Spalding.
Culley, Robert. Bank of Ireland, Dublin.
1878. §Culverwell, Joseph Pope. St. Lawrence Lodge, Sutton, Dublin.
1859. ‡Cumming, Sir A. P. Gordon, Bart. Altyre.
1874. ‡Cumming, Professor. 33 Wellington-place, Belfast.
1861. *Cunliffe, Edward Thomas. The Elms, Handforth, Manchester.
1861. *Cunliffe, Peter Gibson. The Elms, Handforth, Manchester.
1877. §§Cunningham, D. J., M.D. University of Edinburgh.
1852. ‡Cunningham, John. Macedon, near Belfast.
1869. ‡Cunningham, Robert O., M.D., F.L.S., Professor of Natural History in Queen's College, Belfast.
1855. ‡Cunningham, William A. 2 Broadwalk, Buxton.
1850. ‡Cunningham, Rev. William Bruce. Prestonpans, Scotland.
1866. ‡Cunnington, John. 68 Oakley-square, Bedford New Town, London, N.W.
1867. *Cursetjee, Manockjee, F.R.G.S., Judge of Bombay. Villa-Byculla, Bombay.
1857. ‡Curtis, Professor Arthur Hill, LL.D. Queen's College, Galway.

Year of Election.

1878. §Curtis, William. Caramore, Sutton, Co. Dublin.
1834. *Cuthbert, John Richmond. 40 Chapel-street, Liverpool.

1863. ‡Daglish, John. Hetton, Durham.
1854. ‡Daglish, Robert, C.E. Orrell Cottage, near Wigan.
1863. ‡Dale, J. B. South Shields.
1853. ‡Dale, Rev. P. Steele, M.A. Hollingfare, Warrington.
1865. ‡Dale, Rev. R. W. 12 Calthorpe-street, Birmingham.
1867. ‡Dalgleish, W. Dundee.
1870. ‡Dallinger, Rev. W. H. The Parsonage, Woolton, Liverpool.
Dalmahoy, James, F.R.S.E. 9 Forres-street, Edinburgh.
1859. ‡Dalrymple, Charles Elphinstone. West Hall, Aberdeenshire.
1859. ‡Dalrymple, Colonel. Troup, Scotland.
Dalton, Edward, LL.D., F.S.A. Dunkirk House, Nailsworth.
*Dalton, Rev. J. E., B.D. Seagrave, Loughborough.
Dalziel, John, M.D. Holm of Drumlanrig, Thornhill, Dumfriesshire.
1862. ‡Danby, T. W. Downing College, Cambridge.
1859. ‡Dancer, J. B., F.R.A.S. Old Manor House, Ardwick, Manchester.
1873. ‡*Danehill, F. H. Vale Hall, Horwich, Bolton, Lancashire.*
1876. ‡Dansken, John. 4 Eldon-terrace, Partickhill, Glasgow.
1849. *Danson, Joseph, F.C.S. Montreal, Canada.
1861. *Darbishire, Robert Dukinfield, B.A., F.G.S. 26 George-street, Manchester.
1876. ‡Darling, G. Erskine. 247 West George-street, Glasgow.
Darwin, Charles R., M.A., F.R.S., F.L.S., F.G.S., Hon. F.R.S.E. and M.R.I.A. Down, near Bromley, Kent.
1878. §Darwin, Horace. Down, near Bromley, Kent.
1848. ‡DaSilva, Johnson. Burntwood, Wandsworth Common, London, S.W.
1878. §§D'Aulmay, G. 22 Upper Leeson-street, Dublin.
1872. §§Davenport, John T. 64 Marine Parade, Brighton.
Davey, Richard, F.G.S. Redruth, Cornwall.
1870. ‡Davidson, Alexander, M.D. 8 Peel-street, Toxteth Park, Liverpool.
1859. ‡Davidson, Charles. Grove House, Auchmull, Aberdeen.
1871. ‡Davidson, James. Newbattle, Dalkeith, N.B.
1859. ‡Davidson, Patrick. Inchmarlo, near Aberdeen.
1872. ‡Davidson, Thomas, F.R.S., F.G.S. 3 Leopold-road, Brighton.
1875. ‡Davies, David. 2 Queen's-square, Bristol.
1870. ‡Davies, Edward, F.C.S. Royal Institution, Liverpool.
1863. ‡*Davies, Griffith. 17 Cloudesley-street, Islington, London, N.*
1842. Davies-Colley, Dr. Thomas. Newton, near Chester.
1873. *Davis, Alfred. Sun Foundry, Leeds.
1870. *Davis, A. S. Mornington Villa, Leckhampton-road, Cheltenham.
1864. ‡Davis, Charles E., F.S.A. 55 Pulteney-street, Bath.
Davis, Rev. David, B.A. Lancaster.
1873. *Davis, James W., F.G.S., F.S.A. Chevinedge, near Halifax.
1856. *Davis, Sir John Francis, Bart., K.C.B., F.R.S., F.R.G.S. Hollywood, near Compton, Bristol.
1859. ‡Davis, J. Barnard, M.D., F.R.S., F.S.A. Shelton, Hanley, Staffordshire.
1859. *Davis, Richard, F.L.S. 9 St. Helen's-place, London, E.C.
1873. ‡Davis, William Samuel. 1 Cambridge Villas, Derby.
1864. *Davison, Richard. Beverley-road, Great Driffield, Yorkshire.
1857. ‡Davy, Edmund W., M.D. Kimmage Lodge, Roundtown, near Dublin.
1869. ‡Daw, John. Mount Radford, Exeter.

Year of Election.

1869. ‡Daw, R. M. Bedford-circus, Exeter.
1854. *Dawbarn, William. Elmswood, Aigburth, Liverpool.
Dawes, John Samuel, F.G.S. Lappel Lodge, Quinton, near Birmingham.
1860. *Dawes, John T., jun. Llanferris, Mold, North Wales.
1864. ‡Dawkins, W. Boyd, M.A., F.R.S., F.G.S., F.S.A. Birchview, Norman-road, Rusholme, Manchester.
Dawson, John. Barley House, Exeter.
1855. ‡Dawson, John W., M.A., LL.D., F.R.S., F.G.S., Principal of M'Gill College, Montreal, Canada.
1859. *Dawson, Captain William G. Plumstead Common-road, Kent, S.E.
1879. §Day, Francis. Kenilworth House, Cheltenham.
1871. ‡Day, St. John Vincent, C.E., F.R.S.E. 166 Buchanan-street, Glasgow.
1870. §Deacon, G. F., M.I.C.E. Rock Ferry, Liverpool.
1861. ‡Deacon, Henry. Appleton House, near Warrington.
1859. ‡*Dean, David. Banchory, Aberdeen.*
1861. ‡Dean, Henry. Colne, Lancashire.
1870. *Deane, Rev. George, B.A., D.Sc., F.G.S. Spring Hill College, Moseley, near Birmingham.
1866. ‡Debus, Heinrich, Ph.D., F.R.S., F.C.S., Lecturer on Chemistry at Guy's Hospital, London, S.E.
1878. §Delany, Rev. William. St. Stanislaus College, Tullamore.
1854. *De La Rue, Warren, M.A., D.C.L., Ph.D., F.R.S., F.C.S., F.R.A.S. 73 Portland-place, London, W.
1879. §De la Sala, Colonel. Sevilla House, Navarino-road, London, N.W.
1870. ‡De Meschin, Thomas, M.A., LL.D. 4 Hare-court, Temple, London, E.C.
Denchar, John. Morningside, Edinburgh.
1875. ‡Denny, William. Seven Ship-yard, Dumbarton.
Dent, William Yerbury. Royal Arsenal, Woolwich.
1870. *Denton, J. Bailey. 22 Whitehall-place, London, S.W.
1874. §De Rance, Charles E., F.G.S. 28 Jermyn-street, London, S.W.
1856. *Derby, The Right Hon. the Earl of, LL.D., F.R.S., F.R.G.S. 23 St. James's-square, London, S.W.; and Knowsley, near Liverpool.
1874. *Derham, Walter, M.A., LL.M., F.G.S. Henleaze Park, Westbury-on-Trym, Bristol.
1878. §§De Rinzy, James Harward. Khelat Survey, Sukkur, India.
De Saumarez, Rev. Havilland, M.A. St. Peter's Rectory, Northampton.
1868. ‡Dessé, Etheldred, M.B., F.R.C.S. 43 Kensington Gardens-square, Bayswater, London, W.
De Tabley, George, Lord, F.Z.S. Tabley House, Knutsford, Cheshire.
1869. ‡Devon, The Right Hon. the Earl of, D.C.L. Powderham Castle, near Exeter.
*Devonshire, His Grace the Duke of, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S., Chancellor of the University of Cambridge. Devonshire House, Piccadilly, London, W.; and Chatsworth, Derbyshire.
1868. ‡Dewar, James, M.A., F.R.S., F.R.S.E., Fullerian Professor of Chemistry in the Royal Institution, London, and Jacksonian Professor of Natural Experimental Philosophy in the University of Cambridge. Brookside, Cambridge.

Year of Election.

1872. ‡Dewick, Rev. E. S. The College, Eastbourne, Sussex.
1873. *Dew-Smith, A. G. 7A Eaton-square, London, S.W.
1852. ‡Dickie, George, M.A., M.D., F.L.S., Professor of Botany in the University of Aberdeen.
1864. *Dickinson, F. H., F.G.S. Kingweston, Somerton, Taunton; and 121 St. George's-square, London, S.W.
1863. ‡Dickinson, G. T. Claremont-place, Newcastle-on-Tyne.
1867. ‡Dickson, Alexander, M.D., Professor of Botany in the University of Glasgow. 11 Royal-circus, Edinburgh.
1862. *Dilke, Sir Charles Wentworth, Bart., M.P., F.R.G.S. 76 Sloane-street, London, S.W.
1877. §§Dillon, James, C.E. 46 Morehampton-road, Dublin.
1848. ‡Dillwyn, Lewis Llewelyn, M.P., F.L.S., F.G.S. Parkwerne, near Swansea.
1872. §Dines, George. Woodside, Hersham, Walton-on-Thames.
1869. ‡Dingle, Edward. 19 King-street, Tavistock.
1859. *Dingle, Rev. J. Lanchester Vicarage, Durham.
1876. ‡Ditchfield, Arthur. 12 Taviton-street, Gordon-square, London, W.C.
1868. ‡Dittmar, W. Andersonian University, Glasgow.
1874. *Dixon, A. E. Dunowen, Cliftonville, Belfast.
1853. ‡Dixon, Edward, M.I.C.E. Wilton House, Southampton.
1879. §Dixon, Harold B. Balliol College, Oxford.
1861. ‡Dixon, W. Hepworth, F.S.A., F.R.G.S. 6 St. James's-terrace, Regent's Park, London, N.W.
*Dobbin, Leonard, M.R.I.A. 27 Gardiner's-place, Dublin.
1851. ‡Dobbin, Orlando T., LL.D., M.R.I.A. Ballivor, Kells, Co. Meath.
1860. *Dobbs, Archibald Edward, M.A. 34 Westbourne Park, London, W.
1878. *Dobson, G. E., M.A., M.B., F.L.S. Royal Victoria Hospital, Netley, Southampton.
1864. *Dobson, William. Oakwood, Bathwick Hill, Bath.
1875. *Docwra, George, jun. Grosvenor-road, Handsworth, Birmingham.
1870. *Dodd, John. 6 Thomas-street, Liverpool.
1876. ‡Dodds, J. M. 15 Sandyford-place, Glasgow.
*Dodsworth, Benjamin. Burton House, Scarborough.
*Dodsworth, George. The Mount, York.
Dolphin, John. Delves House, Berry Edge, near Gateshead.
1851. ‡Domvile, William C., F.Z.S. Thorn Hill, Bray, Dublin.
1867. ‡Don, John. The Lodge, Broughty Ferry, by Dundee.
1867. ‡Don, William G. St. Margaret's, Broughty Ferry, by Dundee.
1873. ‡Donham, Thomas. Huddersfield.
1869. ‡Donisthorpe, G. T. St. David's Hill, Exeter.
1877. *Donkin, Bryan, jun. May's Hill, Shortlands, Kent.
1874. ‡Donnell, Professor, M.A. 76 Stephen's-green South, Dublin.
1861. ‡Donnelly, Captain, R.E. South Kensington Museum, London, W.
1857. *Donnelly, William, C.B., Registrar-General for Ireland. Charlemont House, Dublin.
1857. ‡Donovan, M., M.R.I.A. Clare-street, Dublin.
1867. ‡Dougall, Andrew Maitland, R.N. Scotscraig, Tayport, Fifeshire.
1871. ‡Dougall, John, M.D. 2 Cecil-place, Paisley-road, Glasgow.
1863. *Doughty, Charles Montagu. Theberton Hall, Saxmundham, Suffolk.
1876. *Douglas, Rev. G. C. M. 10 Fitzroy-place, Glasgow.
1877. *Douglass, James N., C.E. Trinity House, London, E.C.
1878. §§Douglass, William. 104 Baggot-street, Dublin.
1855. ‡*Dove, Hector. Rose Cottage, Trinity, near Edinburgh.*
1870. ‡Dowie, J. M. Wetstones, West Kirby, Cheshire.

Year of Election.

1876. §Dowie, Mrs. Muir. Wetstones, West Kirby, Cheshire.
1878. §§Dowling, Thomas. Claireville House, Terenure, Dublin.
1857. ‡Downing, S., C.E., LL.D., Professor of Civil Engineering in the University of Dublin. 4 The Hill, Monkstown, Co. Dublin.
1878. §§Dowse, The Right Hon. Baron. 38 Mountjoy-square, Dublin.
1872. *Dowson, Edward, M.D. 117 Park-street, London, W.
1865. *Dowson, E. Theodore. Geldeston, near Beccles, Suffolk.
1868. ‡Dresser, Henry E., F.Z.S. 6 Tenterden-street, Hanover-square, London, W.
1873. §§Drew, Frederic, F.G.S., F.R.G.S. Eton College, Windsor.
1869. §Drew, Joseph, LL.D., F.R.A.S., F.G.S. Weymouth.
1879. §Drew, Joseph, M.B. Foxgrove-road, Beckenham, Chapeltown, Edinburgh.
1865. ‡Drew, Robert A. 6 Stanley-place, Duke-street, Broughton, Manchester.
1879. §Drew, Samuel, M.D., D.Sc., F.R.S.E. Chapeltown, Edinburgh.
1872. *Druce, Frederick. 27 Oriental-place, Brighton.
1874. ‡Druitt, Charles. Hampden-terrace, Rugby-road, Belfast.
1859. ‡*Drummond, Robert.* 17 *Stratton-street, London, W.*
1866. *Dry, Thomas. 23 Gloucester-road, Regent's Park, London, N.W.
1870. §Drysdale, J. J., M.D. 36A Rodney-street, Liverpool.
1856. *Ducie, The Right. Hon. Henry John Reynolds Moreton, Earl of, F.R.S., F.G.S. 16 Portman-square, London, W.; and Tortworth Court, Wotton-under-Edge.
1870. ‡Duckworth, Henry, F.L.S., F.G.S. Holmfield House, Grassendale, Liverpool.
1867. *Duff, Mountstuart Elphinstone Grant-, LL.B., M.P. York House, Twickenham, Middlesex.
1852. ‡Dufferin and Clandeboye, The Right Hon. the Earl of, K.P., K.C.B., LL.D., F.R.S. Clandeboye, near Belfast, Ireland.
1877. §§Duffey, George F., M.D. 30 Fitzwilliam-place, Dublin.
1875. §§Duffin, W. E. L'Estrange, C.E. Waterford.
1859. *Duncan, Alexander. 7 Prince's-gate, London, S.W.
1859. ‡Duncan, Charles. 52 Union-place, Aberdeen.
1866. *Duncan, James. 71 Cromwell-road, South Kensington, London, W.
Duncan, J. F., M.D. 8 Upper Merrion-street, Dublin.
1871. ‡Duncan, James Matthew, M.D. 30 Charlotte-square, Edinburgh.
1867. §Duncan, Peter Martin, M.B., F.R.S., F.G.S., Professor of Geology in King's College, London. 4 St. George's-terrace, Regent's Park-road, London, N.W.
Dunlop, Alexander. Clober, Milngavie, near Glasgow.
1853. *Dunlop, William Henry. Annanhill, Kilmarnock, Ayrshire.
1865. ‡Dunn, David. Annet House, Skelmorlie, by Greenock, N.B.
1876. *Dunn, James. 64 Robertson-street, Glasgow.
1876. ‡Dunnachie, James. 2 West Regent-street, Glasgow.
1878. §§Dunne, D. B., M.A., Ph.D., Professor of Logic in the Catholic University of Ireland. 4 Clanwilliam-place, Dublin.
Dunnington-Jefferson, Rev. Joseph, M.A., F.C.P.S. Thicket Hall, York.
1859. ‡Duns, Rev. John, D.D., F.R.S.E. New College, Edinburgh.
1866. ‡Duprey, Perry. Woodbury Down, Stoke Newington, London, N.
1869. ‡D'Urban, W. S. M., F.L.S. 4 Queen-terrace, Mount Radford, Exeter.
1860. ‡Durham, Arthur Edward, F.R.C.S., F.L.S., Demonstrator of Anatomy, Guy's Hospital. 82 Brook-street, Grosvenor-square, London, W.

Year of Election.

Dykes, Robert. Kilmorie, Torquay, Devon.
1869. §Dymond, Edward E. Oaklands, Aspley Guise, Woburn.

1868. ‡Eade, Peter, M.D. Upper St. Giles's-street, Norwich.
1861. ‡Eadson, Richard. 13 Hyde-road, Manchester.
1877. ‡Earle, Ven. Archdeacon, M.A. West Alvington, Devon.
*Earnshaw, Rev. Samuel, M.A. 14 Broomfield, Sheffield.
1874. §§Eason, Charles. 30 Kenilworth-square, Rathgar, Dublin.
1871. *Easton, Edward, C.E. 7 Delahay-street, Westminster, S.W.
1863. §§Easton, James. Nest House, near Gateshead, Durham.
1876. ‡Easton, John, C.E. Durie House, Abercromby-street, Helensburgh, N.B.
1870. §Eaton, Richard. Nuttall House, Nuttall, Nottinghamshire.
Ebden, Rev. James Collett, M.A., F.R.A.S. Great Stukeley Vicarage, Huntingdonshire.
1861. ‡Ecroyd, William Farrer. Spring Cottage, near Burnley.
1858. *Eddison, Francis. Martinstown, Dorchester.
1870. *Eddison, Dr. John Edwin. 29 Park-square, Leeds.
*Eddy, James Ray, F.G.S. Carleton Grange, Skipton.
Eden, Thomas. Talbot-road, Oxton.
**Edgeworth, Michael P., F.L.S., F.R.A.S. Mastrim House, Anerley, London, S.E.*
1855. ‡Edmiston, Robert. Elmbank-crescent, Glasgow.
1859. ‡Edmond, James. Cardens Haugh, Aberdeen.
1870. *Edmonds, F. B. 72 Portsdown-road, London, W.
1867. *Edward, Allan. Farington Hall, Dundee.
1867. ‡Edward, Charles. Chambers, 8 Bank-street, Dundee.
1867. ‡Edward, James. Balruddery, Dundee.
1855. *Edwards, Professor J. Baker, Ph.D., D.C.L. Montreal, Canada.
1867. ‡Edwards, William. 70 Princes-street, Dundee.
*Egerton, Sir Philip de Malpas Grey, Bart., M.P., F.R.S., F.G.S. Oulton Park, Tarporley, Cheshire.
1859. *Eisdale, David A., M.A. 38 Dublin-street, Edinburgh.
1873. ‡Elcock, Charles. 39 Lyme-street, Shakspere-street, Ardwick, Manchester.
1876. ‡Elder, Mrs. 6 Claremont-terrace, Glasgow.
1868. ‡Elger, Thomas Gwyn Empy, F.R.A.S. St. Mary, Bedford.
Ellacombe, Rev. H. T., F.S.A. Clyst St. George, Topsham, Devon.
1863. ‡Ellenberger, J. L. Worksop.
1855. §Elliot, Robert, F.B.S.E. Wolfelee, Hawick, N.B.
1861. *Elliot, Sir Walter, K.C.S.I., F.R.S., F.L.S. Wolfelee, Hawick, N.B.
1864. ‡Elliott, E. B. Washington, United States.
1872. ‡Elliott, Rev. E. B. 11 Sussex-square, Kemp Town, Brighton.
Elliott, John Fogg. Elvet Hill, Durham.
1879. §Elliott, Joseph W. Knowsley-street, Preston.
1864. *Ellis, Alexander John, B.A., F.R.S., F.S.A. 25 Argyll-road, Kensington, London, W.
1877. ‡Ellis, Arthur Devonshire. School of Mines, Jermyn-street, London, S.W.; and Thurnscoe Hall, Rotherham, Yorkshire.
1875. *Ellis, H. D. Fair Park House, Exeter.
1864. *Ellis, Joseph. Hampton Lodge, Brighton.
1864. ‡Ellis, J. Walter. High House, Thornwaite, Ripley, Yorkshire.
*Ellis, Rev. Robert, A.M. The Institute, St. Saviour's Gate, York.
1869. ‡Ellis, William Horton. Pennsylvania, Exeter.
Ellman, Rev. E. B. Berwick Rectory, near Lewes, Sussex.
1862. ‡Elphinstone, H. W., M.A., F.L.S. Cadogan-place, London, S.W.

Year of Election.

1863. ‡Embleton, Dennis, M.D. Northumberland-street, Newcastle-on-Tyne.
1863. ‡Emery, Rev. W., B.D. Corpus Christi College, Cambridge.
1858. ‡Empson, Christopher. Bramhope Hall, Leeds.
1866. ‡Enfield, Richard. Low Pavement, Nottingham.
1866. ‡Enfield, William. Low Pavement, Nottingham.
1853. ‡English, Edgar Wilkins. Yorkshire Banking Company, Lowgate, Hull.
1869. ‡English, J. T. Stratton, Cornwall.
ENNISKILLEN, The Right Hon. WILLIAM WILLOUGHBY, Earl of, LL.D., D.C.L., F.R.S., F.G.S., M.R.I.A. 65 Eaton-place, London, S.W.; and Florence Court, Fermanagh, Ireland.
1869. *Enys, John Davis. Care of F. G. Enys, Esq., Enys, Penryn, Cornwall.
1844. ‡Erichsen, John Eric, F.R.S., F.R.C.S., Professor of Clinical Surgery in University College, London. 6 Cavendish-place, London, W.
1864. *Eskrigge, R. A., F.G.S. 18 Hackins-hey, Liverpool.
1862. *ESSON, WILLIAM, M.A., F.R.S., F.C.S., F.R.A.S. Merton College; and 1 Bradmore-road, Oxford.
1878. §§Estcourt, Charles, F.C.S. 8 St. James's-square, John Dalton-street, Manchester.
Estcourt, Rev. W. J. B. Long Newton, Tetbury.
1869. ‡ETHERIDGE, ROBERT, F.R.S. L. & E., F.G.S., Palæontologist to the Geological Survey of Great Britain. Museum of Practical Geology, Jermyn-street; and 19 Halsey-street, Cadogan-place, London, S.W.
1870. *Evans, Arthur John, F.S.A. Nash Mills, Hemel Hempsted.
1865. *EVANS, Rev. CHARLES, M.A. The Rectory, Solihull, Birmingham.
1872. *Evans, Frederick J., C.E. Clayponds, Brentford, Middlesex, W.
1876. ‡EVANS, Captain FREDERICK J. O., C.B., R.N., F.R.S., F.R.A.S., F.R.G.S., Hydrographer to the Admiralty. 116 Victoria-street, Westminster, S.W.
1869. *Evans, H. Saville W. Wimbledon Park House, Wimbledon, S.W.
1861. *EVANS, JOHN, D.C.L., LL.D., V.P.R.S., F.S.A., F.G.S. 65 Old Bailey, London, E.C.; and Nash Mills, Hemel Hempsted.
1876. ‡Evans, Mortimer, C.E. 97 West Regent-street, Glasgow.
1865. ‡EVANS, SEBASTIAN, M.A., LL.D. Highgate, near Birmingham.
1875. ‡Evans, Sparke. 3 Apsley-road, Clifton, Bristol.
1866. ‡Evans, Thomas, F.G.S. Belper, Derbyshire.
1865. *Evans, William. Ellerslie, Augustus-road, Edgbaston, Birmingham.
1871. §Eve, H. W. Wellington College, Wokingham, Berkshire.
1868. *EVERETT, J. D., D.C.L., F.R.S. L. & E., Professor of Natural Philosophy in Queen's College, Belfast. Rushmere, Malone-road, Belfast.
1863. *Everitt, George Allen, F.R.G.S. Knowle Hall, Warwickshire.
1874. ‡Ewart, William. Glenmachan, Belfast.
1874. ‡Ewart, W. Quartus. Glenmachan, Belfast.
1859. *Ewing, Archibald Orr, M.P. Ballikinrain Castle, Killearn, Stirlingshire.
1876. *Ewing, James Alfred, B.Sc., F.R.S.E., Professor of Mechanical Engineering in the University of Tokio, Japan. 12 Laurel Bank, Dundee.
1871. *Exley, John T., M.A. 1 Cotham-road, Bristol.
1846. *Eyre, George Edward, F.G.S., F.R.G.S. 59 Lowndes-square, London, S.W.; and Warrens, near Lyndhurst, Hants.
1866. ‡EYRE, Major-General Sir VINCENT, F.R.G.S. Athenæum Club, Pall Mall, London, S.W.

Year of Election.

Eyton, Charles. Hendred House, Abingdon.
1849. ‡Eyton, T. C. Eyton, near Wellington, Salop.

1842. *Fairbairn, Thomas. Manchester.*
1865. ‡Fairley, Thomas, F.R.S.E., F.C.S. 8 Newington-grove, Leeds.
1876. ‡Fairlie, James M. Charing Cross Corner, Glasgow.
1870. ‡Fairlie, Robert, C.E. Woodlands, Clapham Common, London, S.W.
1878. *Fairlie, Robert F. Palace-chambers, Victoria-street, Westminster, S.W.
1864. ‡Falkner, F. H. Lyncombe, Bath.
1877. §Faraday, F. J., F.S.S. College Chambers, 17 Brazenose-street, Manchester.
1879. *Farnworth, Ernest. Swindon, near Dudley.
1859. ‡Farquharson, Robert O. Houghton, Aberdeen.
1861. §Farr, William, M.D., D.C.L., F.R.S., Superintendent of the Statistical Department, General Register Office, London. Southlands, Bickley, Kent.
1866. *Farrar, Rev. Frederick William, M.A., D.D., F.R.S., Canon of Westminster. St. Margaret's Rectory, Westminster, S.W.
1857. ‡Farrelly, Rev. Thomas. Royal College, Maynooth.
1869. *Faulding, Joseph. The Grange, Greenhill Park, New Barnet, Herts.
1869. ‡Faulding, W. F. Didsbury College, Manchester.
1859. *Fawcett, Henry, M.A., M.P., Professor of Political Economy in the University of Cambridge. 51 The Lawn, South Lambeth-road, London, S.W.; and 8 Trumpington-street, Cambridge.
1863. ‡Fawcus, George. Alma-place, North Shields.
1873. *Fazakerley, Miss. The Castle, Denbigh.
1845. ‡Felkin, William, F.L.S. The Park, Nottingham.
Fell, John B. Spark's Bridge, Ulverstone, Lancashire.
1864. *Fellows, Frank P., F.S.A., F.S.S. 8 The Green, Hampstead, London, N.W.
1852. ‡Fenton, S. Greame. 9 College-square; and Keswick, near Belfast.
1876. *Fergus, Andrew, M.D. 3 Elmbank-crescent, Glasgow.
1876. ‡Ferguson, Alexander A. 11 Grosvenor-terrace, Glasgow.
1859. ‡Ferguson, John. Cove, Nigg, Inverness.
1871. *Ferguson, John, M.A., Professor of Chemistry in the University of Glasgow.
1867. ‡Ferguson, Robert M., Ph.D., F.R.S.E. 8 Queen-street, Edinburgh.
1857. ‡Ferguson, Samuel, LL.D., Q.C. 20 Great George's-street North, Dublin.
1854. ‡Ferguson, William, F.L.S., F.G.S. Kinmundy, near Mintlaw, Aberdeenshire.
1867. *Fergusson, H. B. 13 Airlie-place, Dundee.
1863. *Fernie, John. Bonchurch, Isle of Wight.
1862. ‡Ferrers, Rev. Norman MacLeod, M.A., F.R.S. Caius College, Cambridge.
1873. ‡Ferrier, David, M.A., M.D., F.R.S., Professor of Forensic Medicine in King's College. 16 Upper Berkeley-street, London, W.
1875. ‡Fiddes, Walter. Clapton Villa, Tyndall's Park, Clifton, Bristol.
1868. ‡Field, Edward. Norwich.
1869. *Field, Rogers, B.A., C.E. 5 Cannon-row, Westminster, S.W.
1876. ‡Fielden, James. 2 Darnley-street, Pollokshields, near Glasgow.
Finch, John. Bridge Work, Chepstow.
Finch, John, jun. Bridge Work, Chepstow.
1878. *Findlater, William. 2 Fitzwilliam-square, Dublin.
1868. ‡Firth, G. W. W. St. Giles's-street, Norwich.
1879. §Firth, Alderman Mark. Oakbrook, Sheffield.

Year of Election.

Firth, Thomas. Northwick.
1863. *Firth, William. Burley Wood, near Leeds.
1851. *Fischer, William L. F., M.A., LL.D., F.R.S. St. Andrews, Scotland.
1858. ‡Fishbourne, Captain E. G., R.N. 6 Welamere-terrace, Paddington, London, W.
1869. ‡Fisher, Rev. Osmond, M.A., F.G.S. Harlston Rectory, near Cambridge.
1873. §Fisher, William. Maes Fron, near Welshpool, Montgomeryshire.
1879. §Fisher, William. Norton Grange, near Sheffield.
1875. *Fisher, W. W., M.A., F.C.S. 2 Park-crescent, Oxford.
1858. ‡Fishwick, Henry. Carr-hill, Rochdale.
1871. *Fison, Frederick W., F.C.S. Eastmoor, Ilkley, Yorkshire.
1871. ‡Fitch, J. G., M.A. 5 Lancaster-terrace, Regent's Park, London, N.W.
1868. ‡Fitch, Robert, F.G.S., F.S.A. Norwich.
1878. §§Fitzgerald, C. E., M.D. 27 Upper Merrion-street, Dublin.
1878. §Fitzgerald, George Francis. Trinity College, Dublin.
1857. ‡Fitzgerald, The Right Hon. Lord Otho. 13 Dominick-street, Dublin.
1857. ‡Fitzpatrick, Thomas, M.D. 31 Lower Baggot-street, Dublin.
1865. ‡Fleetwood, D. J. 45 George-street, St. Paul's, Birmingham.
Fleetwood, Sir Peter Hesketh, Bart. Rossall Hall, Fleetwood, Lancashire.
1850. ‡Fleming, Professor Alexander, M.D. 121 Hagley-road, Birmingham.
Fleming, Christopher, M.D. Merrion-square North, Dublin.
1876. ‡Fleming, James Brown. Beaconsfield, Kelvinside, near Glasgow.
Fleming, John G., M.D. 155 Bath-street, Glasgow.
1876. ‡Fleming, Sandford. Ottawa, Canada.
*Fleming, William, M.D. Rowton Grange, near Chester.
1867. §Fletcher, Alfred E. 5 Edge-lane, Liverpool.
1870. ‡Fletcher, B. Edgington. Norwich.
1869. ‡Fletcher, Lavington E., C.E. 41 Corporation-street, Manchester.
Fletcher, T. B. E., M.D. 7 Waterloo-street, Birmingham.
1862. ‡Flower, William Henry, LL.D., F.R.S., F.L.S., F.G.S., F.R.C.S., Hunterian Professor of Comparative Anatomy, and Conservator of the Museum of the Royal College of Surgeons. Royal College of Surgeons, Lincoln's-Inn-fields, London, W.C.
1877. *Floyer, Ernest A., F.R.G.S. 7 The Terrace, Putney, S.W.
1867. ‡Foggie, William. Woodville, Maryfield, Dundee.
1879. §Foote, Charles Newth, M.D. 3 Albion-place, Sunderland.
1879. §Foote, Harry D'Oyley, M.D. Rotherham, Yorkshire.
1873. *Forbes, Professor George, M.A., F.R.S.E. Andersonian University, Glasgow.
1855. ‡Forbes, Rev. John. Symington Manse, Biggar, Scotland.
1877. §Forbes, W. A. West Wickham, Kent.
Ford, H. R. Morecombe Lodge, Yealand Conyers, Lancashire.
1866. ‡Ford, William. Hartsdown Villa, Kensington Park-gardens East, London, W.
1875. *Fordham, H. George, F.G.S. Odsey, near Royston, Herts.
*Forrest, William Hutton. 1 Pitt-terrace, Stirling.
1867. ‡Forster, Anthony. Finlay House, St. Leonard's-on-Sea.
1858. *Forster, The Right Hon. William Edward, M.P., F.R.S. 80 Eccleston-square, London, S.W.; and Wharfeside, Burley-in-Wharfedale, Leeds.
1854. *Fort, Richard. Read Hall, Whalley, Lancashire.
1877. ‡Fortescue, The Right Hon. the Earl. Castle Hill, North Devon.
1870. ‡Forwood, William B. Hopeton House, Seaforth, Liverpool.

Year of Election.

1875. ‡Foster, A. Le Neve. East Hill, Wandsworth, Surrey, S.W.
1865. ‡Foster, Balthazar, M.D., Professor of Medicine in Queen's College, Birmingham. 16 Temple-row, Birmingham.
1865. *Foster, Clement Le Neve, B.A., D.Sc., F.G.S. Truro, Cornwall.
1857. *Foster, George Carey, B.A., F.R.S., F.C.S., Professor of Physics in University College, London. 12 Hilldrop-road, London, N.
*Foster, Rev. John, M.A. The Oaks Vicarage, Loughborough.
1845. ‡Foster, John N. Sandy Place, Sandy, Bedfordshire.
1877. §Foster, Joseph B. 6 James-street, Plymouth.
1859. *Foster, Michael, M.A., M.D., F.R.S., F.L.S., F.C.S. Trinity College, and Great Shelford, near Cambridge.
1873. ‡*Foster, Peter Le Neve.*
1863. ‡Foster, Robert. 30 Rye-hill, Newcastle-upon-Tyne.
1859. *Foster, S. Lloyd. Brundall Lodge, Ealing, Middlesex, W.
1873. *Foster, William. Harrowins House, Queensbury, Yorkshire.
1842. *Fothergill, Benjamin.* 10 *The Grove, Boltons, West Brompton, London, S.W.*
1870. ‡Foulger, Edward. 55 Kirkdale-road, Liverpool.
1866. ‡Fowler, George, M.I.C.E., F.G.S. Basford Hall, near Nottingham.
1868. ‡Fowler, G. G. Gunton Hall, Lowestoft, Suffolk.
1876. *Fowler, John. 4 Kelvin Bank-terrace, Glasgow.
1870. *Fowler, Robert Nicholas, M.A., F.R.G.S. 50 Cornhill, London, E.C.
1868. ‡Fox, *Major-General A. H.* Lane, *F.R.S., F.G.S., F.R.G.S., F.S.A.* Penywern-road, South Kensington, London, S.W.
*Fox, Rev. Edward, M.A. Upper Heyford, Banbury.
1876. ‡Fox, G. S. Lane. 9 Sussex-place, London, S.W.
*Fox, Joseph Hayland. The Cleve, Wellington, Somerset.
1860. ‡Fox, Joseph John. Church-row, Stoke Newington, London, N.
1866. *Francis, G. B. Inglesby House, Stoke Newington-green, London, N.
Francis, William, Ph.D., F.L.S., F.G.S., F.R.A.S. Red Lion-court, Fleet-street, London, E.C.; and Manor House, Richmond, Surrey.
1846. ‡Frankland, Edward, D.C.L., Ph.D., F.R.S., F.C.S., Professor of Chemistry in the Royal School of Mines. 14 Lancaster-gate, London, W.
*Frankland, Rev. Marmaduke Charles. Chowbent, near Manchester.
1859. ‡Fraser, George B. 3 Airlie-place, Dundee.
Fraser, James. 25 Westland-row, Dublin.
Fraser, James William. 8A Kensington Palace-gardens, London, W.
1865. *Fraser, John, M.A., M.D. Chapel Ash, Wolverhampton.
1871. ‡Fraser, Thomas R., M.D., F.R.S.L. & E. 3 Grosvenor-street, Edinburgh.
1859. *Frazer, Daniel. 113 Buchanan-street, Glasgow.
1871. ‡Frazer, Evan L. R. Brunswick-terrace, Spring Bank, Hull.
1860. ‡Freeborn, Richard Fernandez. 38 Broad-street, Oxford.
1847. *Freeland, Humphrey William, F.G.S. West-street, Chichester, Sussex.
1877. §Freeman, Francis Ford. Blackfriars House, Plymouth.
1865. ‡Freeman, James. 15 Francis-road, Edgbaston, Birmingham.
Frere, George Edward, F.R.S. Roydon Hall, Diss, Norfolk.
1869. ‡Frere, The Right Hon. Sir H. Bartle E., Bart., G.C.S.I., G.C.B., F.R.S., F.R.G.S., Governor of Cape Colony and Dependencies. Government House, Cape Town.
1869. ‡Frere, Rev. William Edward. The Rectory, Bilton, near Bristol.

Year of Election.

1857. *Frith, Richard Hastings, C.E., M.R.I.A., F.R.G.S.I. 48 Summerhill, Dublin.
1869. ‡Frodsham, Charles. 26 Upper Bedford-place, Russell-square, London, W.C.
1847. ‡Frost, William. Wentworth Lodge, Upper Tulse Hill, London, S.W.
1875. ‡Fry, F. J. 104 Pembroke-road, Clifton, Bristol.
Fry, Francis. Cotham, Bristol.
1875. *Fry, Joseph Storrs. 2 Charlotte-street, Bristol.
Fry, Richard. Cotham Lawn, Bristol.
1872. *Fuller, Rev. A. Pallant, Chichester.
1873. ‡*Fuller, Claude S., R.N.* 44 *Holland-road, Kensington, London, W.*
1859. ‡Fuller, Frederick, M.A., Professor of Mathematics in the University and King's College, Aberdeen.
1869. ‡Fuller, George, C.E., Professor of Engineering in Queen's College, Belfast. 6 College-gardens, Belfast.
1864. *Furneaux, Rev. Alan. St. German's Parsonage, Cornwall.

*Gadesden, Augustus William, F.S.A. Ewell Castle, Surrey.
1857. ‡Gages, Alphonse, M.R.I.A. Museum of Irish Industry, Dublin.
1863. *Gainsford, W. D. Richmond Hill, Sheffield.
1876. ‡Gairdner, Charles. Broom, Newton Mearns, Renfrewshire.
1850. ‡Gairdner, Professor W. T., M.D. 225 St. Vincent-street, Glasgow.
1861. ‡Galbraith, Andrew. Glasgow.
Galbraith, Rev. J. A., M.A., M.R.I.A. Trinity College, Dublin.
1876. ‡Gale, James M. 23 Miller-street, Glasgow.
1863. ‡Gale, Samuel, F.C.S. 338 Oxford-street, London, W.
1861. ‡Galloway, Charles John. Knott Mill Iron Works, Manchester.
1861. ‡Galloway, John, jun. Knott Mill Iron Works, Manchester.
1875. §§Galloway, W., H.M. Inspector of Mines. Cardiff.
1860. *Galton, Captain Douglas, C.B., D.C.L., F.R.S., F.L.S., F.G.S., F.R.G.S. (General Secretary.) 12 Chester-street, Grosvenor-place, London, S.W.
1860. *Galton, Francis, M.A., F.R.S., F.G.S., F.R.G.S. 42 Rutland-gate, Knightsbridge, London, S.W.
1869. ‡Galton, John C., M.A., F.L.S. 13 Margaret-street, Cavendish-square, London, W.
1870. §Gamble, Lieut.-Colonel D. St. Helen's, Lancashire.
1870. ‡Gamble, J. C. St. Helen's, Lancashire.
1872. *Gamble, John G., M.A. 10 Vyvyan-terrace, Clifton, Bristol; and Albion House, Rottingdean, Brighton.
1877. ‡Gamble, William. St. Helen's, Lancashire.
1868. ‡Gamgee, Arthur, M.D., F.R.S., F.R.S.E., Professor of Physiology in Owens College, Manchester. Fairview, Princes-road, Fallowfield, Manchester.
1862. §Garner, Robert, F.L.S. Stoke-upon-Trent.
1865. §Garner, Mrs. Robert. Stoke-upon-Trent.
1842. Garnett, Jeremiah. Warren-street, Manchester.
1873. ‡Garnham, John. 123 Bunhill-row, London, E.C.
1874. *Garstin, John Ribton, M.A., LL.B., M.R.I.A., F.S.A. Bragans-town, Castlebellingham, Ireland.
1870. ‡Gaskell, Holbrook. Woolton Wood, Liverpool.
1870. *Gaskell, Holbrook, jun. Mayfield-road, Grassendale, Liverpool.
1847. *Gaskell, Samuel. Windham Club, St. James's-square, London, S.W.
1842. Gaskell, Rev. William, M.A. Plymouth-grove, Manchester.
1862. *Gatty, Charles Henry, M.A., F.L.S., F.G.S. Felbridge Park, East Grinstead, Sussex.
1875. §Gavey, J. 45 Stacey-road, Routh, Cardiff.

Year of Election.

1875. §§Gaye, Henry S. Newton Abbott, Devon.
1873. ‡*Geach, R. G. Cragg Wood, Rawdon, Yorkshire.*
1871. ‡Geddes, John. 9 Melville-crescent, Edinburgh.
1859. ‡Geddes in William D., M.A., Professor of Greek in King's College, Old Aberdeen.
1854. ‡Gee, Robert, M.D. 5 Abercromby-square, Liverpool.
1867. ‡Geikie, Archibald, LL.D., F.R.S. L. & E., F.G.S., Director of the Geological Survey of Scotland. Geological Survey Office, Victoria-street, Edinburgh; and Boroughfield, Edinburgh.
1871. §§Geikie, James, F.R.S. L. & E., F.G.S. 16 Duncan-terrace, Newington, Edinburgh.
1855. ‡*Gemmell, Andrew.* 38 *Queen-street, Glasgow.*
1875. *George, Rev. Hereford B., M.A., F.R.G.S. New College, Oxford.
1854. ‡*Gerard, Henry.* 8A *Rumford-place, Liverpool.*
1870. ‡Gerstl, R. University College, London, W.C.
1870. *Gervis, Walter S., M.D., F.R.G.S. Ashburton, Devonshire.
1856. *Gething, George Barkley. Springfield, Newport, Monmouthshire.
1865. ‡Gibbins, William. Battery Works, Digbeth, Birmingham.
1871. ‡*Gibson, Alexander.* 10 *Albany-street, Edinburgh.*
1868. ‡Gibson, C. M. Bethel-street, Norwich.
1874. ‡Gibson, Edward, Q.C. 23 Fitzwilliam-square, Dublin.
1876. *Gibson, George Alexander, M.B., D.Sc., F.G.S. 10 Old-square, Birmingham.
*Gibson, George Stacey. Saffron Walden, Essex.
1852. ‡Gibson, James, M.A., Q.C. 35 Mountjoy-square South, Dublin.
1870. ‡Gibson, Thomas. 51 Oxford-street, Liverpool.
1870. ‡Gibson, Thomas, jun. 10 Parkfield-road, Prince's Park, Liverpool.
1842. Gilbert, Joseph Henry, Ph.D., F.R.S., F.C.S. Harpenden, near St. Albans.
1857. ‡Gilbert, J. T., M.R.I.A. Villa Nova, Blackrock, Dublin.
1859. *Gilchrist, James, M.D. Crichton House, Dumfries.
Gilderdale, Rev. John, M.A. Walthamstow, Essex.
1878. §Giles, Oliver. 16 Bellevue-crescent, Clifton, Bristol.
Giles, Rev. William. Netherleigh House, near Chester.
1878. §§Gill, Rev. A. W. H. 44 Eaton-square, London, S.W.
1871. *Gill, David. The Observatory, Cape Town.
1868. ‡Gill, Joseph. Palermo, Sicily. (Care of W. H. Gill, Esq., General Post Office, St. Martin's-le-Grand, E.C.)
1864. ‡Gill, Thomas. 4 Sydney-place, Bath.
1861. *Gilroy, George. Hindley Hall, Wigan.
1867. ‡Gilroy, Robert. Craigie, by Dundee.
1876. §Gimingham, Charles H. 45 St. Augustine's-road, Camden-square, London, N.W.
1867. §§Ginsburg, Rev. C. D., D.C.L., LL.D. Wokingham, Berkshire.
1869. ‡Girdlestone, Rev. Canon E., M.A. Halberton Vicarage, Tiverton.
1874. *Girdwood, James Kennedy. Old Park, Belfast.
1850. *Gladstone, George, F.C.S., F.R.G.S. 31 Ventnor-villas, Cliftonville, Brighton.
1849. *Gladstone, John Hall, Ph.D., F.R.S., F.C.S. 17 Pembridge-square, Hyde Park, London, W.
1861. **Gladstone, Murray.* 35 *Wilton-crescent, London, S.W.*
1875. *Glaisher, Ernest Henry. 1 Dartmouth-place, Blackheath, London, S.E.
1861. *Glaisher, James, F.R.S., F.R.A.S. 1 Dartmouth-place, Blackheath, London, S.E.
1871. *Glaisher, J. W. L., M.A., F.R.S., F.R.A.S. Trinity College, Cambridge.

Year of Election.

1853. ‡Gleadon, Thomas Ward. Moira-buildings, Hull.
1870. §Glen, David Corse, F.G.S. 14 Annfield-place, Glasgow.
1859. ‡Glennie, J. S. Stuart. 6 Stone-buildings, Lincoln's Inn, London, W.C.
1867. ‡Gloag, John A. L. 10 Inverleith-place, Edinburgh.
Glover, George. Ranelagh-road, Pimlico, London, S.W.
1874. §§Glover, George T. 30 Donegall-place, Belfast.
Glover, Thomas. Becley Old Hall, Rowsley, Bakewell.
1874. ‡Glover, Thomas. 77 Claverton-street, London, S.W.
1870. ‡Glynn, Thomas R. 1 Rodney-street, Liverpool.
1872. ‡Goddard, Richard. 16 Booth-street, Bradford, Yorkshire.
1878. *Godlee, J. Lister. 3 New-square, Lincoln's Inn, London, W.C.
1852. ‡Godwin, John. Wood House, Rostrevor, Belfast.
1846. ‡Godwin-Austen, Robert A. C., B.A., F.R.S., F.G.S. Shalford House, Guildford.
1876. ‡Goff, Bruce, M.D. Bothwell, Lanarkshire.
1877. §§Goff, James. 11 Northumberland-road, Dublin.
1873. ‡Goldthorp, Miss R. F. C. Cleckheaton, Bradford, Yorkshire.
1878. §§Good, Rev. Thomas, B.D. 51 Wellington-road, Dublin.
1852. ‡Goodbody, Jonathan. Clare, King's County, Ireland.
1870. ‡Goodison, George William, C.E. Gateacre, Liverpool.
1842. *Goodman, John, M.D. 8 Leicester-street, Southport.
1865. ‡Goodman, J. D. Minories, Birmingham.
1869. ‡Goodman, Neville. Peterhouse, Cambridge.
1870. *Goodwin, Rev. Henry Albert, M.A., F.R.A.S. Lambourne Rectory, Romford.
1878. §Gordon, J. E. H., B.A. (Assistant Secretary.) Holmwood Cottage, Dorking.
1871. *Gordon, Joseph Gordon, F.C.S. 20 King-street, St. James's, London, S.W.
1840. ‡*Gordon, Lewis D. B. Totteridge, Whetstone, London, N.*
1857. ‡Gordon, Samuel, M.D. 11 Hume-street, Dublin.
1865. ‡Gore, George, LL.D., F.R.S. 50 Islington-row, Edgbaston, Birmingham.
1870. ‡Gossage, William. Winwood, Woolton, Liverpool.
1875. *Gotch, Francis. Stokes Croft, Bristol.
*Gotch, Rev. Frederick William, LL.D. Stokes Croft, Bristol.
*Gotch, Thomas Henry. Kettering.
1873. §Gott, Charles, M.I.C.E. Parkfield-road, Manningham, Bradford, Yorkshire.
1849. ‡Gough, The Hon. Frederick. Perry Hall, Birmingham.
1857. ‡Gough, The Right Hon. George S., Viscount, M.A., F.L.S., F.G.S. St. Helen's, Booterstown, Dublin.
1868. ‡Gould, Rev. George. Unthank-road, Norwich.
Gould, John, F.R.S., F.L.S., F.R.G.S., F.Z.S. 26 Charlotte-street, Bedford-square, London, W.C.
1873. ‡Gourlay, J. McMillan. 21 St. Andrew's-place, Bradford, Yorkshire.
1867. ‡Gourley, Henry (Engineer). Dundee.
1876. §Gow, Robert. Cairndowan, Dowanhill, Glasgow.
Gowland, James. London-wall, London, E.C.
1873. §Goyder, Dr. D. Marley House, 88 Great Horton-road, Bradford, Yorkshire.
1861. ‡Grafton, Frederick W. Park-road, Whalley Range, Manchester.
1867. *Graham, Cyril, F.L.S., F.R.G.S. Colonial Office, London, S.W.
1875. ‡Grahame, James. Auldhouse, Pollokshaws, near Glasgow.
1852. *Grainger, Rev. John, D.D., M.R.I.A. Skerry and Rathcavan Rectory, Broughshane, near Ballymena, Co. Antrim.

Year of Election.

1871. ‡Grant, Sir Alexander, Bart., M.A., Principal of the University of Edinburgh. 21 Lansdowne-crescent, Edinburgh.
1870. ‡Grant, Colonel J. A., C.B., C.S.I., F.R.S., F.L.S., F.R.G.S. 19 Upper Grosvenor-street, London, W.
1859. ‡Grant, Hon. James. Cluny Cottage, Forres.
1855. *Grant, Robert, M.A., LL.D., F.R.S., F.R.A.S., Regius Professor of Astronomy in the University of Glasgow. The Observatory, Glasgow.
1854. ‡Grantham, Richard B., C.E., F.G.S. 22 Whitehall-place, London, S.W.
1864. ‡Grantham, Richard F. 22 Whitehall-place, London, S.W.
1874. ‡Graves, Rev. James, B.A., M.R.I.A. Inisnag Glebe, Stonyford, Co. Kilkenny.
1864. *Gray, Rev. Charles. The Vicarage, Blyth, Worksop.
1865. ‡Gray, Charles. Swan-bank, Bilston.
1870. ‡Gray, C. B. 5 Rumford-place, Liverpool.
1876. ‡Gray, Dr. Newton-terrace, Glasgow.
1857. ‡Gray, Sir John, M.D. Rathgar, Dublin.
1864. ‡Gray, Jonathan. Summerhill House, Bath.
1859. ‡Gray, Rev. J. H. Bolsover Castle, Derbyshire.
1870. §§Gray, J. Macfarlane. 127 Queen's-road, Peckham, London, S.E.
1878. §§Gray, Matthew Hamilton. 14 St. John's Park, Blackheath, London, S.E.
1878. §§Gray, Robert Kaye. 14 St. John's Park, Blackheath, London, S.E.
1873. ‡Gray, William, M.R.I.A. 6 Mount Charles, Belfast.
*Gray, William, F.G.S. Gray's-court, Minster Yard, York.
*Gray, Colonel William. Farley Hall, near Reading.
1854. *Grazebrook, Henry. Clent Grove, near Stourbridge, Worcestershire.
1866. §Greaves, Charles Augustus, M.B., LL.B. 101 Friar-gate, Derby.
1873. ‡*Greaves, James H., C.E. Albert-buildings, Queen Victoria-street, London, E.C.*
1869. §Greaves, William. Station-street, Nottingham.
1872. §§Greaves, William. 11 John-street, Bedford-row, London, W.C.
1872. *Grece, Clair J., LL.D. Redhill, Surrey.
1879. §Green, A. F. Leeds.
1858. *Greenhalgh, Thomas. Thornydikes, Sharples, near Bolton-le-Moors.
1863. ‡Greenwell, G. E. Poynton, Cheshire.
1875. ‡Greenwood, Frederick. School of Medicine, Leeds.
1862. *Greenwood, Henry. 32 Castle-street, and the Woodlands, Anfield-road, Anfield, Liverpool.
1877. §§Greenwood, Holmes. 78 King-street, Accrington.
1849. ‡Greenwood, William. Stones, Todmorden.
1861. *Greg, Robert Philips, F.G.S., F.R.A.S. Coles Park, Buntingford, Herts.
1833. Gregg, T. H. 22 Ironmonger-lane, Cheapside, London, E.C.
1860. ‡Gregor, Rev. Walter, M.A. Pitsligo, Rosehearty, Aberdeenshire.
1868. ‡Gregory, Charles Hutton, C.E. 1 Delahay-street, Westminster, S.W.
1861. §Gregson, Samuel Leigh. Aigburth-road, Liverpool.
1875. ‡Grenfell, J. Granville, B.A., F.G.S. 5 Albert-villas, Clifton, Bristol.
*Greswell, Rev. Richard, M.A., F.R.S., F.R.G.S. 39 St. Giles's-street, Oxford.
1869. ‡Grey, Sir George, F.R.G.S. Belgrave-mansions, Grosvenor-gardens, London, S.W.
1875. ‡Grey, Mrs. Maria G. 18 Cadogan-place, London, S.W.

Year of Election.

1871. *Grierson, Samuel, Medical Superintendent of the District Asylum, Melrose, N.B.
1859. ‡Grierson, Thomas Boyle, M.D. Thornhill, Dumfriesshire.
1875. §Grieve, David, F.R.S.E., F.G.S. Hobart House, Dalkeith, Edinburgh.
1870. ‡Grieve, John, M.D. 21 Lynedock-street, Glasgow.
1878. §§Griffin, Robert, M.A., LL.D. Trinity College, Dublin.
Griffith, Rev. C. T., D.D. Elm, near Frome, Somerset.
1859. *Griffith, George, M.A., F.C.S. Harrow.
Griffith, George R. Fitzwilliam-place, Dublin.
1870. ‡Griffith, Rev. Henry, F.G.S. Barnet, Herts.
1868. ‡Griffith, Rev. John, M.A., D.C.L. Findon Rectory, Worthing, Sussex.
1870. ‡Griffith, N. R. The Coppa, Mold, North Wales.
1847. ‡Griffith, Thomas. Bradford-street, Birmingham.
Griffiths, Rev. John, M.A. Wadham College, Oxford.
1879. §Griffiths, Thomas, F.C.S., F.S.S. Silverdale, Oxton, Birkenhead.
1875. ‡Grignon, James, H.M. Consul at Riga. Riga.
1870. ‡Grimsdale, T. F., M.D. 29 Rodney-street, Liverpool.
1842. Grimshaw, Samuel, M.A. Errwod, Buxton.
1864. ‡Groom-Napier, Charles Ottley, F.G.S. 18 Elgin-road, St. Peter's Park, London, N.W.
1869. §Grote, Arthur, F.L.S., F.G.S. 20 Cork-street, Burlington-gardens, London, W.
Grove, The Hon. Sir William Robert, Knt., M.A., Ph.D., F.R.S. 115 Harley-street, London, W.
1863. *Groves, Thomas B., F.C.S. 80 St. Mary-street, Weymouth.
1869. ‡Grubb, Howard, F.R.A.S. 40 Leinster-square, Rathmines, Dublin.
1872. ‡Grüneisen, Charles Lewis, F.R.G.S. 16 Surrey-street, Strand, London, W.C.
Guest, Edwin, M.A., LL.D., F.R.S., Master of Caius College, Cambridge. Caius Lodge, Cambridge; and Sandford Park, Oxfordshire.
1867. ‡Guild, John. Bayfield, West Ferry, Dundee.
Guinness, Henry. 17 College-green, Dublin.
1842. Guinness, Richard Seymour. 17 College-green, Dublin.
1856. *Guise, Sir William Vernon, Bart., F.G.S., F.L.S. Elmore Court, near Gloucester.
1862. ‡Gunn, John, M.A., F.G.S. Irstedd Rectory, Norwich.
1877. §§Gunn, William, F.G.S. Barnard Castle, Darlington.
1866. ‡Günther, Albert C. L. G., M.A., M.D., Ph.D., F.R.S., Keeper of the Zoological Collections in the British Museum. British Museum, London, W.C.
1868. *Gurney, John. Sprouston Hall, Norwich.
1860. *Gurney, Samuel, F.L.S., F.R.G.S. 29 Hanover-terrace, Regent's Park, London, N.W.
*Gutch, John James. Holgate Lodge, York.
1876. ‡Guthrie, Francis. Cape Town, Cape of Good Hope.
1859. ‡Guthrie, Frederick, B.A., F.R.S. L. & E., Professor of Physics in the Royal School of Mines. Science Schools, South Kensington, London, S.W.
1857. ‡Gwynne, Rev. John. Tullyagnish, Letterkenny, Strabane, Ireland.
1876. ‡Gwyther, R. F. Owens College, Manchester.

Hackett, Michael. Brooklawn, Chapelizod, Dublin.
1865. ‡Hackney, William. 9 Victoria-chambers, Victoria-street, London, S.W.

Year of Election.

1866. *Hadden, Frederick J. 3 Park-terrace, Nottingham.
1866. ‡Haddon, Henry. Lenton Field, Nottingham.
Haden, G. N. Trowbridge, Wiltshire.
1842. Hadfield, George. Victoria-park, Manchester.
1870. ‡Hadivan, Isaac. 3 Huskisson-street, Liverpool.
1848. ‡Hadland, William Jenkins. Banbury, Oxfordshire.
1870. ‡Haigh, George. Waterloo, Liverpool.
*Hailstone, Edward, F.S.A. Walton Hall, Wakefield, Yorkshire.
1879. §Hake, H. Wilson, Ph.D., F.C.S. Queenswood College, Hants.
1869. ‡Hake, R. C. Grasmere Lodge, Addison-road, Kensington, London, W.
1875.§§Hale, Rev. Edward, M.A., F.G.S., F.R.G.S. Eton College, Windsor.
1870. ‡Halhead, W. B. 7 Parkfield-road, Liverpool.
Halifax, The Right Hon. Viscount. 10 Belgrave-square, London, S.W.; and Hickleston Hall, Doncaster.
1872. ‡Hall, Dr. Alfred. 30 Old Steine, Brighton.
1879. *Hall, Ebenezer. Abbeydale Park, near Sheffield.
1854. *Hall, Hugh Fergie, F.G.S. Greenheys, Wallasey, Birkenhead.
1859. ‡Hall, John Frederic. Ellerker House, Richmond, Surrey.
1872. *Hall, Captain Marshall. Scientific Club, Savile-row, London, W.
*Hall, Thomas B. Australia. (Care of J. P. Hall, Esq., Crane House, Great Yarmouth.)
1866. *Hall, Townshend M., F.G.S. Pilton, Barnstaple.
1860.§§Hall, Walter. 11 Pier-road, Erith.
1873. *Hallett, T. G. P., M.A. Claverton Lodge, Bath.
1868. *Hallett, William Henry, F.L.S. Buckingham House, Marine Parade, Brighton.
Halsall, Edward. 4 Somerset-street, Kingsdown, Bristol.
1858. *Hambly, Charles Hambly Burbridge, F.G.S. The Leys, Barrow-on-Soar, near Loughborough.
1866. §Hamilton, Archibald, F.G.S. South Barrow, Bromley, Kent.
1865.§§Hamilton, Gilbert. Leicester House, Kenilworth-road, Leamington.
Hamilton, The Very Rev. Henry Parr, Dean of Salisbury, M.A., F.R.S. L. & E., F.G.S., F.R.A.S. Salisbury.
1869. ‡Hamilton, John, F.G.S. Fyne Court, Bridgewater.
1869. §Hamilton, Roland. Oriental Club, Hanover-square, London, W.
1851. ‡Hammond, C. C. Lower Brook-street, Ipswich.
1878.§§Hanagan, Anthony. Luckington, Dalkey.
1878. §Hance, Edward M., LL.B. 24 Church-road, Wavertree, Liverpool.
1875. ‡Hancock, C. F., jun., M.A. 36 Blandford-square, London, N.W.
1863. ‡Hancock, John. 4 St. Mary's-terrace, Newcastle-on-Tyne.
1850. ‡Hancock, John, J.P. The Manor House, Lurgan, Co. Armagh.
1861. ‡Hancock, Walker. 10 Upper Chadwell-street, Pentonville, London, N.
1857. ‡Hancock, William J. 23 Synnot-place, Dublin.
1847. ‡Hancock, W. Neilson, LL.D., M.R.I.A. 64 Upper Gardiner-street, Dublin.
1876.§§Hancock, Mrs. W. Neilson. 64 Upper Gardiner-street, Dublin.
1865. ‡Hands, M. Coventry
Handyside, P. D., M.D., F.R.S.E. Edinburgh.
1867. ‡Hannah, Rev. John, D.C.L. The Vicarage, Brighton.
1859. ‡Hannay, John. Montcoffer House, Aberdeen.
1853. ‡Hansell, Thomas T. 2 Charlotte-street, Sculcoates, Hull.
*Harcourt, A. G. Vernon, M.A., F.R.S., F.C.S. Cowley Grange, Oxford.

Year of Election.

Harcourt, Egerton V. Vernon, M.A., F.G.S. Whitwell Hall, Yorkshire.
1865. ‡Harding, Charles. Harborne Heath, Birmingham.
1869. ‡Harding, Joseph. Millbrooke House, Exeter.
1877. §Harding, Stephen. Bower Ashton, Clifton, Bristol.
1869. ‡Harding, William D. Islington Lodge, King's Lynn, Norfolk.
1874. ‡Hardman, E. T., F.C.S. 14 Hume-street, Dublin.
1872. ‡Hardwicke, Mrs. 192 Piccadilly, London, W.
*Hare, Charles John, M.D., Professor of Clinical Medicine in University College, London. 57 Brook-street, Grosvenor-square, London, W.
Harford, Summers. Haverfordwest.
1858. ‡Hargrave, James. Burley, near Leeds.
1876. ‡Harker, Allen. 17 Southgate-street, Gloucester.
1878. *Harkness, H. W. Sacramento, California.
1871. §§Harkness, William. Laboratory, Somerset House, London, W.C.
1875. *Harland, Rev. Albert Augustus, M.A., F.G.S., F.L.S., F.S.A. The Vicarage, Harefield, Middlesex.
1877. *Harland, Henry Seaton. Brompton, Wykeham Station, York.
1862. *Harley, George, M.D., F.R.S., F.C.S. 25 Harley-street, London, W.
*Harley, John. Ross Hall, near Shrewsbury.
1862. *Harley, Rev. Robert, F.R.S., F.R.A.S. Mill Hill School, Middlesex; and Burton Bank, Mill Hill, Middlesex, N.W.
1861. ‡*Harman, H. W., C.E.* 16 *Booth-street, Manchester.*
1868. *Harmer, F. W., F.G.S. Oakland House, Cringleford, Norwich.
1872. §§Harpley, Rev. William, M.A., F.C.P.S. Clayhanger Rectory, Tiverton.
*Harris, Alfred. Oxton Hall, Tadcaster.
*Harris, Alfred, jun. Lunefield, Kirkby-Lonsdale, Westmoreland.
1871. ‡Harris, George, F.S.A. Iselipps Manor, Northolt, Southall, Middlesex.
1878. *Harris, Herbert W. 124 Lower Baggot-street, Dublin.
1863. ‡Harris, T. W. Grange, Middlesbrough-on-Tees.
1873. ‡Harris, W. W. Oak-villas, Bradford, Yorkshire.
1860. ‡Harrison, Rev. Francis, M.A. Oriel College, Oxford.
1864. ‡Harrison, George. Barnsley, Yorkshire.
1873. ‡Harrison, George, Ph.D., F.L.S., F.C.S. 14 St. James's-row, Sheffield.
1874. ‡Harrison, G. D. B. 3 Beaufort-road, Clifton, Bristol.
1858. *Harrison, James Park, M.A. 80 Westbourne Park-road, London, W.
1870. ‡Harrison, Reginald. 51 Rodney-street, Liverpool.
1853. ‡Harrison, Robert. 36 George-street, Hull.
1863. ‡Harrison, T. E. Engineers' Office, Central Station, Newcastle-on-Tyne.
1853. *Harrison, William, F.S.A., F.G.S. Samlesbury Hall, near Preston, Lancashire.
1849. ‡Harrowby, The Right Hon. Dudley Ryder, Earl of, K.G., D.C.L., F.R.S., F.R.G.S. 39 Grosvenor-square, London, W.; and Sandon Hall, Lichfield.
1859. *Hart, Charles. Harborne Hall, Birmingham.
1876. *Hart, Thomas. Bank View, 33 Preston New-road, Blackburn.
1875. §§Hart, W. E. Kilderry, near Londonderry.
1856. ‡*Hartland, F. Dixon, F.S.A., F.R.G.S. The Oaklands, near Cheltenham.*
Hartley, James. Sunderland.

Year of Election.

1871. ‡Hartley, Walter Noel, F.C.S., Professor of Chemistry in the Royal College of Science, Dublin.
1854. §§Hartnup, John, F.R.A.S. Liverpool Observatory, Bidston, Birkenhead.
1850. ‡Harvey, Alexander. 4 South Wellington-place, Glasgow.
1870. ‡Harvey, Enoch. Riversdale-road, Aigburth, Liverpool.
*Harvey, Joseph Charles. Knockrea, Douglas-road, Cork.
Harvey, J. R., M.D. St. Patrick's-place, Cork.
1878. §§Harvey, R. J., M.D. 7 Upper Merrion-street, Dublin.
1862. *Harwood, John, jun. Woodside Mills, Bolton-le-Moors.
1875. ‡Hasting, G. W. Barnard's Green House, Malvern.
Hastings, Rev. H. S. Martley Rectory, Worcester.
1837. ‡*Hastings, W. Huddersfield.*
1842. *Hatton, James. Richmond House, Higher Broughton, Manchester.
1857. ‡Haughton, Rev. Samuel, M.A., M.D., D.C.L., F.R.S., M.R.I.A., F.G.S., Professor of Geology in the University of Dublin. Trinity College, Dublin.
1874. ‡Hawkins, B. Waterhouse, F.G.S. Century Club, East Fifteenth-street, New York.
1872. *Hawkshaw, Henry Paul. 20 King-street, St. James's, London, S.W.
*Hawkshaw, Sir John, C.E., F.R.S., F.G.S., F.R.G.S. Hollycombe, Liphook, Petersfield; and 33 Great George-street, London, S.W.
1864. *Hawkshaw, John Clarke, M.A., F.G.S. 25 Cornwall-gardens, South Kensington, S.W.; and 33 Great George-street, London, S.W.
1868. ‡Hawksley, Thomas, C.E., F.R.S., F.G.S. 30 Great George-street, London, S.W.
1863. ‡Hawthorn, William. The Cottage, Benwell, Newcastle-upon-Tyne.
1859. ‡Hay, Sir Andrew Leith, Bart. Rannes, Aberdeenshire.
1877. §§Hay, Arthur J. Lerwick, Shetland.
1861. *Hay, Rear-Admiral the Right Hon. Sir John C. D., Bart., C.B., M.P., D.C.L., F.R.S. 108 St. George's-square, London, S.W.
1858. ‡Hay, Samuel. Albion-place, Leeds.
1867. ‡Hay, William. 21 Magdalen-yard-road, Dundee.
1857. ‡Hayden, Thomas, M.D. 30 Harcourt-street, Dublin.
1873. *Hayes, Rev. William A., M.A. 3 Mountjoy-place, Dublin.
1869. ‡Hayward, J. High-street, Exeter.
1858. *Hayward, Robert Baldwin, M.A., F.R.S. The Park, Harrow.
1879. §Hazlehurst, George S. The Elms, Runcorn.
1851. §Head, Jeremiah, C.E., F.C.S. Middlesbrough, Yorkshire.
1869. ‡Head, R. T. The Briars, Alphington, Exeter.
1869. ‡Head, W. R. Bedford-circus, Exeter.
1863. ‡Heald, Joseph. 22 Leazes-terrace, Newcastle-on-Tyne.
1872. ‡*Healey, C. E. H. Chadwyck.* 8 *Albert-mansions, Victoria-street, London, S.W.*
1871. §Healey, George. Matson's, Windermere.
1861. *Heape, Benjamin. Northwood, Prestwich, near Manchester.
1877. ‡Hearder, Henry Pollington. Westwell-street, Plymouth.
1865. ‡Hearder, William. Rocombe, Torquay.
1877. ‡Hearder, William Keep, F.S.A. 195 Union-street, Plymouth.
1866. ‡Heath, Rev. D. J. Esher, Surrey.
1863. ‡Heath, G. Y., M.D. Westgate-street, Newcastle-on-Tyne.
1861. §§Heathfield, W. E., F.C.S., F.R.G.S., F.R.S.E. 20 King-street, St. James's, London, S.W.
1865. ‡Heaton, Harry. Harborne House, Harborne, near Birmingham.
1858. *Heaton, John Deakin, M.D., F.R.C.P. Claremont, Leeds.

Year of Election.

1865. ‡*Heaton, Ralph. Harborne Lodge, near Birmingham.*
1833. ‡Heaviside, Rev. Canon J. W. L., M.A. The Close, Norwich.
1855. ‡Hector, James, M.D., F.R.S., F.G.S., F.R.G.S., Geological Survey of New Zealand. Wellington, New Zealand.
1867. ‡Heddle, M. Foster, M.D., Professor of Chemistry in the University of St. Andrews, N.B.
1869. ‡Hedgeland, Rev. W. J. 21 Mount Radford, Exeter.
1863. ‡Hedley, Thomas. Cox Lodge, near Newcastle-on-Tyne.
1857. *Hemans, George William, C.E., M.R.I.A., F.G.S. 1 Westminster-chambers, Victoria-street, London, S.W.
1867. ‡Henderson, Alexander. Dundee.
1845. ‡Henderson, Andrew. 120 Gloucester-place, Portman-square, London, W.
1873. *Henderson, A. L. 49 King William-street, London, E.C.
1874. ‡Henderson, James Alexander. Norwood Tower, Belfast.
1876. *Henderson, William. Williamfield, Irvine, N.B.
1873. *Henderson, W. D. 12 Victoria-street, Belfast.
1856. ‡Hennessy, Henry G., F.R.S., M.R.I.A., Professor of Applied Mathematics and Mechanics in the Royal College of Science for Ireland. 3 Idrone-terrace, Blackrock, Co. Dublin.
1857. ‡Hennessy, John Pope, Governor of the Bahamas. Government House, Nassau.
1873. *Henrici, Olaus M. F. E., Ph.D., F.R.S., Professor of Mathematics in University College, London. 21 South-villas, Camden-square, London, N.W.
Henry, Franklin. Portland-street, Manchester.
Henry, J. Snowdon. East Dene, Bonchurch, Isle of Wight.
Henry, Mitchell, M.P. Stratheden House, Hyde Park, London, W.
1874. ‡Henry, Rev. P. Shuldam, D.D., M.R.I.A., Belfast.
*Henry, William Charles, M.D., F.R.S., F.G.S., F.R.G.S., F.C.S. Haffield, near Ledbury, Herefordshire.
1870. ‡Henty, William. 12 Medina-villas, Brighton.
1855. *Hepburn, J. Gotch, LL.B., F.C.S. Sidcup-place, Sidcup, Kent.
1855. ‡Hepburn, Robert. 9 Portland-place, London, W.
Hepburn, Thomas. Clapham, London, S.W.
1871. ‡*Hepburn, Thomas H. St. Mary's Cray, Kent.*
Hepworth, John Mason. Ackworth, Yorkshire.
1856. ‡Hepworth, Rev. Robert. 2 St. James's-square, Cheltenham.
1866. ‡Herrick, Perry. Bean Manor Park, Loughborough.
1871. *Herschel, Professor Alexander S., B.A., F.R.A.S. College of Science, Newcastle-on-Tyne.
1874. §§Herschel, Major John, R.E., F.R.S. Mussoorie, N. W. P. India. (Care of Messrs. H. Robertson & Co., 5 Crosby-square, London, E.C.)
1865. ‡Heslop, Dr. Birmingham.
1873. ‡*Heugh, John. Gaunt's House, Wimborne, Dorset.*
Hey, Rev. William, M.A., F.C.P.S. Clifton, York.
1866. *Heymann, Albert. West Bridgford, Nottinghamshire.
1866. ‡Heymann, L. West Bridgford, Nottinghamshire.
1879. §Heywood, A. Percival. Duffield Bank, Derby.
1861. *Heywood, Arthur Henry. Elleray, Windermere.
*Heywood, James, F.R.S., F.G.S., F.S.A., F.R.G.S., F.S.S. 26 Kensington Palace-gardens, London, W.
1861. *Heywood, Oliver. Claremont, Manchester.
Heywood, Thomas Percival. Claremont, Manchester.
1875. ‡Hicks, Henry, M.D., F.G.S. Heriot House, Hendon, Middlesex, N.W.

Year of Election.

1877. §§Hicks, W. M. St. John's College, Cambridge.
1864. *Hiern, W. P., M.A. Castle House, Barnstaple.
1854. *Higgin, Edward. Troston Lodge, near Bury St. Edmunds.
1861. *Higgin, James. Lancaster-avenue, Fennel-street, Manchester.
Higginbotham, Samuel. 4 Springfield-court, Queen-street, Glasgow.
1866. ‡Higginbottom, John, F.R.S., F.R.C.S. Gill-street, Nottingham.
1875. ‡Higgins, Charles Hayes, M.D., M.R.C.P., F.R.C.S., F.R.S.E. Alfred House, Birkenhead.
1871. ‡Higgins, Clement, B.A., F.C.S. 103 Holland-road, Kensington, London, W.
1854. ‡Higgins, Rev. Henry H., M.A. The Asylum, Rainhill, Liverpool.
1861. *Higgins, James. Stocks House, Cheetham, Manchester.
1870. ‡*Higginson, Alfred. 44 Upper Parliament-street, Liverpool.*
Hildyard, Rev. James, B.D., F.C.P.S. Ingoldsby, near Grantham, Lincolnshire.
Hill, Arthur. Bruce Castle, Tottenham, Middlesex.
1872. §Hill, Charles, F.S.A. Rockhurst, West Hoathley, East Grinstead.
*Hill, Rev. Edward, M.A., F.G.S. Sheering Rectory, Harlow.
1857. §Hill, John, C.E., M.R.I.A., F.R.G.S.I. County Surveyor's Office, Ennis, Ireland.
1871. ‡Hill, Lawrence. The Knowe, Greenock.
1864. ‡*Hill, William. Combe Hay, Bristol.*
1876. ‡Hill, William H. Barlanark, Shettleston, N.B.
1863. ‡Hills, F. C. Chemical Works, Deptford, Kent, S.E.
1871. *Hills, Thomas Hyde. 338 Oxford-street, London, W.
1858. ‡Hincks, Rev. Thomas, B.A., F.R.S. Stancliff House, Clevedon, Somerset.
1870. ‡Hinde, G. J. Buenos Ayres.
Hindley, Rev. H. J. Edlington, Lincolnshire.
*Hindmarsh, Luke. Alnbank House, Alnwick.
1865. ‡Hinds, James, M.D. Queen's College, Birmingham.
1863. ‡Hinds, William, M.D. Parade, Birmingham.
1861. **Hinmers, William. Cleveland House, Birkdale, Southport.*
1858. ‡Hirst, John, jun. Dobcross, near Manchester.
1861. *Hirst, T. Archer, Ph.D., F.R.S., F.R.A.S. Royal Naval College, Greenwich, S.E.; and Athenæum Club, Pall Mall, London, S.W.
1856. ‡*Hitch, Samuel, M.D. Sandywell Park, Gloucestershire.*
1870. ‡Hitchman, William, M.D., LL.D., F.L.S. 29 Erskine-street, Liverpool.
*Hoare, Rev. George Tooker. Godstone Rectory, Redhill.
Hoare, J. Gurney. Hampstead, London, N.W.
1864. ‡Hobhouse, Arthur Fane. 24 Cadogan-place, London, S.W.
1864. ‡Hobhouse, Charles Parry. 24 Cadogan-place, London, S.W.
1864. ‡Hobhouse, Henry William. 24 Cadogan-place, London, S.W.
1879. §Hobkirk, Charles P., F.L.S. Huddersfield.
1879. §Hobson, John. Tapton Elms, Sheffield.
1866. ‡Hockin, Charles, M.D. 8 Avenue-road, St. John's Wood, London, N.W.
1877. ‡Hockin, Edward. Poughill, Stratton, Cornwall.
1877. §§Hodge, Rev. John Mackey, M.A. 38 Tavistock-place, Plymouth.
1876. ‡Hodges, Frederick W. Queen's College, Belfast.
1852. ‡Hodges, John F., M.D., F.C.S., Professor of Agriculture in Queen's College, Belfast.

Year of Election.

1863. *Hodgkin, Thomas. Benwell Dene, Newcastle-on-Tyne.
1873. *Hodgson, George. Thornton-road, Bradford, Yorkshire.
1873. ‡Hodgson, James. Oakfield, Manningham, Bradford, Yorkshire.
1863. ‡Hodgson, Robert. Whitburn, Sunderland.
1863. ‡Hodgson, R. W. North Dene, Gateshead.
1830. ‡Hodgson, W. B., LL.D., F.R.A.S., Professor of Commercial and Political Economy in the University of Edinburgh.
1865. *Hofmann, August Wilhelm, M.D., LL.D., Ph.D., F.R.S., F.C.S. 10 Dorotheen Strasse, Berlin.
1860. ‡Hogan, Rev. A. R., M.A. Watlington Vicarage, Oxfordshire.
1876. ‡*Hogg, Robert.* 54 *Jane-street, Glasgow.*
1854. *Holcroft, George. Byron's-court, St. Mary's-gate, Manchester.
1873. *Holden, Isaac. Oakworth House, near Keighley, Yorkshire.
1879. §Holland, Calvert Bernard. Ashdell, Broomhill, Sheffield.
1856. ‡Holland, Henry. Dumbleton, Evesham.
*Holland, Philip H. Home Office, London, S.W.
1879. *Holland, Rev. F. W., M.A. Evesham.
1865. ‡Holliday, William. New-street, Birmingham.
1866. *Holmes, Charles. 59 London-road, Derby.
1873. ‡Holmes, J. R. Southbrook Lodge, Bradford, Yorkshire.
1876. *Holms, James. Hope Park, Partick, near Glasgow.
1876. ‡Holms, Colonel William, M.P. 95 Cromwell-road, South Kensington, London, S.W.
1870. ‡Holt, William D. 23 Edge-lane, Liverpool.
*Hone, Nathaniel, M.A., M.R.I.A. Bank of Ireland, Dublin.
1875. *Hood, John. The Elms, Cotham Hill, Bristol.
1847. ‡Hooker, Sir Joseph Dalton, K.C.S.I., K.C.B., M.D., D.C.L., LL.D., F.R.S., V.P.L.S., F.G.S., F.R.G.S. Royal Gardens, Kew, Surrey.
1865. *Hooper, John P. Coventry Park, Streatham, London, S.W.
1877. *Hooper, Samuel F., B.A. Tamworth House, Mitcham Common, Surrey.
1856. ‡Hooton, Jonathan. 80 Great Ducie-street, Manchester.
1842. Hope, Thomas Arthur. Stanton, Bebington, Cheshire.
1869. ‡*Hope, William, V.C. Parsloes, Barking, Essex.*
1865. ‡Hopkins, J. S. Jesmond Grove, Edgbaston, Birmingham.
1870. *Hopkinson, John, F.R.S. 78 Holland-road, Kensington, London, W.
1871. §Hopkinson, John, F.L.S., F.G.S. Wansford House, Watford.
1858. ‡Hopkinson, Joseph, jun. Britannia Works, Huddersfield.
Hornby, Hugh. Sandown, Liverpool.
1876. *Horne, Robert R. 150 Hope-street, Glasgow.
1875. *Horniman, F. J. Surrey House, Forest Hill, London, S.E.
1854. ‡Horsfall, Thomas Berry. Bellamour Park, Rugeley.
1856. ‡Horsley, John H. 1 Ormond-terrace, Cheltenham.
1868. ‡Hotson, W. C. Upper King-street, Norwich.
Houghton, The Right Hon. Lord, M.A., D.C.L., F.R.S., F.R.G.S. 16 Upper Brook-street, London, W.
1858. ‡Hounsfield, James. Hemsworth, Pontefract.
Hovenden, W. F., M.A. Bath.
1859. ‡*Howard, Captain John Henry, R.N. The Deanery, Lichfield.*
1879. *Howard, D. South Frith Lodge, Tonbridge.
1863. ‡Howard, Philip Henry. Corby Castle, Carlisle.
1876. ‡Howatt, James. 146 Buchanan-street, Glasgow.
1857. ‡Howell, Henry H., F.G.S. Museum of Practical Geology, Jermyn-street, London, S.W.
1868. ‡Howell, Rev. Canon Hinds. Drayton Rectory, near Norwich.

Year of Election.

1865. *Howlett, Rev. Frederick, F.R.A.S. East Tisted Rectory, Alton, Hants.
1863. ‡Howorth, H. H. Derby House, Eccles, Manchester.
1854. ‡Howson, The Very Rev. J. S., D.D., Dean of Chester. Chester.
1870. ‡Hubback, Joseph. 1 Brunswick-street, Liverpool.
1835. *Hudson, Henry, M.D., M.R.I.A. Glenville, Fermoy, Co. Cork.
1842. §Hudson, Robert, F.R.S., F.G.S., F.L.S. Clapham Common, London, S.W.
1879. §Hudson, Robert S., M.D. Redruth, Cornwall.
1867. ‡Hudson, William H. H., M.A. 19 Bennet's-hill, Doctors' Commons, London, E.C.; and St. John's College, Cambridge.
1858. *Huggins, William, D.C.L. Oxon., LL.D. Camb., F.R.S., F.R.A.S. Upper Tulse Hill, Brixton, London, S.W.
1857. ‡Huggon, William. 30 Park-row, Leeds.
1871. *Hughes, George Pringle, J.P. Middleton Hall, Wooler, Northumberland.
1870. *Hughes, Lewis. Fenwick-court, Liverpool.
1876. *Hughes, Rev. Thomas Edward. Wallfield, Reigate.
1868. §§Hughes, T. M'K., M.A., F.G.S., Woodwardian Professor of Geology in the University of Cambridge.
1863. ‡Hughes, T. W. 4 Hawthorn-terrace, Newcastle-on-Tyne.
1865. ‡Hughes, W. R., F.L.S., Treasurer of the Borough of Birmingham. Birmingham.
1867. §§Hull, Edward, M.A., F.R.S., F.G.S., Director of the Geological Survey of Ireland, and Professor of Geology in the Royal College of Science. 14 Hume-street, Dublin.
*Hulse, Sir Edward, Bart., D.C.L. 47 Portland-place, London, W.; and Breamore House, Salisbury.
1861. ‡Hume, Rev. Canon Abraham, D.C.L., LL.D., F.S.A. All Souls' Vicarage, Rupert-lane, Liverpool.
1878. §§Humphreys, H. Castle-square, Carnarvon.
1856. ‡Humphries, David James. 1 Keynsham-parade, Cheltenham.
1862. *Humphry, George Murray, M.D., F.R.S., Professor of Anatomy in the University of Cambridge. Grove Lodge, Cambridge.
1877. *Hunt, Arthur Roope, M.A., F.G.S. Southwood, Torquay.
1865. ‡Hunt, J. P. Gospel Oak Works, Tipton.
1840. ‡Hunt, Robert, F.R.S., Keeper of the Mining Records. Museum of Practical Geology, Jermyn-street, London, S.W.
1864. ‡Hunt, W. 72 Pulteney-street, Bath.
1875. *Hunt, William. The Woodlands, Tyndall's Park, Clifton, Bristol.
Hunter, Andrew Galloway. Denholm, Hawick, N.B.
1868. ‡Hunter, Christopher. Alliance Insurance Office, North Shields.
1867. ‡Hunter, David. Blackness, Dundee.
1869. *Hunter, Rev. Robert, F.G.S. 9 Mecklenburgh-street, London, W.C.
1879. §Huntington, A. K. Abbeville House, Arkwright-road, Hampstead, London, N.W.
1863. ‡Huntsman, Benjamin. West Retford Hall, Retford.
1875. ‡Hurnard, James. Lexden, Colchester, Essex.
1869. ‡Hurst, George. Bedford.
1861. *Hurst, William John. Drumaness Mills, Ballynahinch, Lisburn, Ireland.
1870. ‡Hurter, Dr. Ferdinand. Appleton, Widnes, near Warrington.
Husband, William Dalla. Coney-street, York.
1876. ‡Hutchinson, John. 22 Hamilton Park-terrace, Glasgow.
1874. ‡Hutchinson, Thomas J., F.R.G.S. Chimoo Cottage, Mill Hill, London, N.W.

Year of Election.

1876. ‡*Hutchison, Peter.* 28 *Berkeley-terrace, Glasgow.*
1868. *Hutchison, Robert, F.R.S.E. 29 Chester-street, Edinburgh.
1863. ‡*Hutt, The Right Hon. Sir W., K.C.B. Gibside, Gateshead.*
Hutton, Crompton. Putney Park, Surrey, S.W.
1864. *Hutton, Darnton. (Care of Arthur Lupton, Esq., Headingley, near Leeds.)
Hutton, Henry. Edenfield, Dundrum, Co. Dublin.
1857. ‡Hutton, Henry D. 10 Lower Mountjoy-street, Dublin.
1861. *Hutton, T. Maxwell. Summerhill, Dublin.
1852. ‡Huxley, Thomas Henry, Ph.D., LL.D., Sec. R.S., F.L.S., F.G.S., Professor of Natural History in the Royal School of Mines. 4 Marlborough-place, London, N.W.
Hyde, Edward. Dukinfield, near Manchester.
1871. *Hyett, Francis A. Painswick House, Stroud, Gloucestershire.

1879. §Ibbotson, H. J. 26 Collegiate-crescent, Sheffield.
Ihne, William, Ph.D. Heidelberg.
1873. §Ikin, J. I. 19 Park-place, Leeds.
1861. ‡Iles, Rev. J. H. Rectory, Wolverhampton.
1858. ‡Ingham, Henry. Wortley, near Leeds.
1876.§§Inglis, Anthony. Broomhill, Partick, Glasgow.
1871. ‡Inglis, The Right Hon. John, D.C.L., LL.D., Lord Justice General of Scotland. Edinburgh.
1876. ‡Inglis, John, jun. Prince's-terrace, Dowanhill, Glasgow.
1858. *Ingram, Hugo Francis Meynell. Temple Newsam, Leeds.
1852. ‡Ingram, J. K., LL.D., M.R.I.A., Regius Professor of Greek in the University of Dublin. 2 Wellington-road, Dublin.
1870. *Inman, William. Upton Manor, Liverpool.
Ireland, R. S., M.D. 121 Stephen's-green, Dublin.
1857. ‡Irvine, Hans, M.A., M.B. 1 Rutland-square, Dublin.
1862. ‡Iselin, J. F., M.A., F.G.S. South Kensington Museum, London, S.W.
1863. *Ivory, Thomas. 23 Walker-street, Edinburgh.

1865. ‡Jabet, George. Wellington-road, Handsworth, Birmingham.
1870. ‡Jack, James. 26 Abercromby-square, Liverpool.
1859. ‡Jack, John, M.A. Belhelvie-by-Whitecairns, Aberdeenshire.
1876. ‡Jack, William. 19 Lansdowne-road, Notting Hill, London, W.
1879. §Jackson, Arthur, F.R.C.S. Wilkinson-street, Sheffield.
1866. ‡Jackson, H. W., F.R.A.S., F.G.S. 15 The Terrace, High-road, Lewisham, S.E.
1869. §Jackson, Moses. The Vale, Ramsgate.
Jackson, Professor Thomas, LL.D. St. Andrew's, Scotland.
1863. *Jackson-Gwilt, Mrs. H. Moonbeam Villa, The Grove, New Wimbledon, London, S.W.
1852. ‡Jacobs, Bethel. 40 George-street, Hull.
1874. *Jaffe, John. Cambridge Villa, Strandtown, near Belfast.
1865. *Jaffray, John. Park-grove, Edgbaston, Birmingham.
1872. ‡James, Christopher. 8 Laurence Pountney Hill, London, E.C.
1860. ‡James, Edward H. Woodside, Plymouth.
1863. *James, Sir Walter, Bart., F.G.S. 6 Whitehall-gardens, London, S.W.
1858. ‡James, William C. Woodside, Plymouth.
1876. ‡Jamieson, J. L. K. The Mansion House, Govan, Glasgow.
1876. ‡Jamieson, Rev. Dr. R. 156 Randolph-terrace, Glasgow.
1859. *Jamieson, Thomas F., F.G.S. Ellon, Aberdeenshire.
1850. ‡Jardine, Alexander. Jardine Hall, Lockerby, Dumfriesshire.

Year of Election.

1870. ‡Jardine, Edward. Beach Lawn, Waterloo, Liverpool.
1853. *Jarratt, Rev. Canon J., M.A. North Cave, near Brough, Yorkshire.
JARRETT, Rev. THOMAS, M.A., Professor of Arabic in the University of Cambridge. Trunch, Norfolk.
1870. §§Jarrold, John James. London-street, Norwich.
1862. ‡Jeakes, Rev. James, M.A. 54 Argyll-road, Kensington, London, W.
Jebb, Rev. John. Peterstow Rectory, Ross, Herefordshire.
1868. ‡*Jecks, Charles.* 26 *Langham-place, Northampton.*
1856. ‡Jeffery, Henry M., M.A. 438 High-street, Cheltenham.
1855. *Jeffray, John. Cardowan House, Millerston, Glasgow.
1867. ‡Jeffreys, Howel, M.A., F.R.A.S. 5 Brick-court, Temple, London, E.C.
1861. *JEFFREYS, J. GWYN, LL.D., F.R.S., F.L.S., Treas. G.S., F.R.G.S. Ware Priory, Herts.
1852. ‡JELLETT, Rev. JOHN H., B.D., M.R.I.A. 64 Lower Leeson-street, Dublin.
1862. §§JENKIN, H. C. FLEEMING, F.R.S., M.I.C.E., Professor of Civil Engineering in the University of Edinburgh. 3 Great Stuart-street, Edinburgh.
1873. §Jenkins, Major-General J. J. 14 St. James's-square, London, S.W.
Jennette, Matthew. 106 Conway-street, Birkenhead.
1852. ‡Jennings, Francis M., F.G.S., M.R.I.A. Brown-street, Cork.
1872. ‡Jennings, W. Grand Hotel, Brighton.
1878. §§Jephson, Henry L. Chief Secretary's Office, The Castle, Dublin.
*Jerram, Rev. S. John, M.A. Chobham Vicarage, near Bagshot, Surrey.
1872. ‡Jesson, Thomas. 7 Upper Wimpole-street, Cavendish-square, London, W.
Jessop, William, jun. Butterley Hall, Derbyshire.
1870. *JEVONS, W. STANLEY, M.A., LL.D., F.R.S., Professor of Political Economy in University College, London. 2 The Chestnuts, Branch Hill, Hampstead Heath, London, N.W.
1872. *Joad, George C. Oakfield, Wimbledon, Surrey, S.W.
1871. *Johnson, David, F.C.S., F.G.S. Irvon Villa, Grosvenor-road, Wrexham.
1865. *Johnson, G. J. 36 Waterloo-street, Birmingham.
1875. §Johnson, James Henry, F.G.S., F.S.A. 73 Albert-road, Southport.
1866. ‡Johnson, John. Knighton Fields, Leicester.
1866. ‡Johnson, John G. 18A Basinghall-street, London, E.C.
1872. ‡Johnson, J. T. 27 Dale-street, Manchester.
1861. ‡Johnson, Richard. 27 Dale-street, Manchester.
1870. §Johnson, Richard C., F.R.A.S. Higher Bebington Hall, Birkenhead.
1863. ‡Johnson, R. S. Hanwell, Fence Houses, Durham.
*Johnson, Thomas. Bache Hurst, Liverpool-road, Chester.
1861. ‡Johnson, William Beckett. Woodlands Bank, near Altrincham.
1871. ‡Johnston, A. Keith, F.R.G.S. 1 Savile-row, London, W.
1864. ‡Johnston, David. 13 Marlborough-buildings, Bath.
1859. ‡Johnston, James. Newmill, Elgin, N.B.
1864. ‡Johnston, James. Manor House, Northend, Hampstead, London, N.W.
1876. ‡*Johnston, John, M.D. Edinburgh.*
*Johnstone, James. Alva House, Alva, by Stirling, N.B.
1864. ‡Johnstone, John. 1 Barnard-villas, Bath.
1876. ‡Johnstone, William. 5 Woodside-terrace, Glasgow.

Year of Election.

1864. ‡Jolly, Thomas. Park View-villas, Bath.
1871. §§Jolly, William (H.M. Inspector of Schools). Inverness, N.B.
1849. ‡Jones, Baynham. Selkirk Villa, Cheltenham.
1856. ‡Jones, C. W. 7 Grosvenor-place, Cheltenham.
1877. §Jones, Henry C., F.C.S. 166 Blackstock-road, London, N.
1865. ‡*Jones, John.* 49 *Union-passage, Birmingham.*
*Jones, Robert. 2 Castle-street, Liverpool.
1873. ‡Jones, Theodore B. 1 Finsbury-circus, London, E.C.
1860. ‡Jones, Thomas Rupert, F.R.S., F.G.S., Professor of Geology and Mineralogy, Royal Military and Staff Colleges, Sandhurst. Fosse Bank, Camberley, Surrey.
1847. ‡Jones, Thomas Rymer, F.R.S. 52 Cornwall-road, Westbourne Park, London, W.
1864. §§Jones, Sir Willoughby, Bart., F.R.G.S. Cranmer Hall, Fakenham, Norfolk.
1875. *Jose, J. E. 3 Queen-square, Bristol.
*Joule, Benjamin St. John B. 28 Leicester-street, Southport, Lancashire.
1842. *Joule, James Prescott, LL.D., F.R.S., F.C.S. 12 Wardle-road, Sale, near Manchester.
1847. ‡Jowett, Rev. B., M.A., Regius Professor of Greek in the University of Oxford. Balliol College, Oxford.
1858. ‡Jowett, John. Leeds.
1879. §Jowitt, A. Hawthorn Lodge, Clarkehouse-road, Sheffield.
1872. ‡Joy, Algernon. Junior United Service Club, St. James's, London, S.W.
1848. *Joy, Rev. Charles Ashfield. Grove Parsonage, Wantage, Berkshire.
Joy, Rev. John Holmes, M.A. 3 Coloney-terrace, Tunbridge Wells.
*Jubb, Abraham. Halifax.
1870. ‡Judd, John Wesley, F.R.S., F.G.S. 6 Manor-view, Brixton, London, S.W.
1863. ‡*Jukes, Rev. Andrew. Spring Bank, Hull.*

1868. *Kaines, Joseph, M.A., D.Sc. 13 Finsbury-place South, London, E.C.
Kane, Sir Robert, M.D., LL.D., F.R.S., M.R.I.A., F.C.S., Principal of the Royal College of Cork. Fortland, Killiney, Co. Dublin.
1857. ‡Kavanagh, James W. Grenville, Rathgar, Ireland.
1859. ‡Kay, David, F.R.G.S. 19 Upper Phillimore-place, Kensington, London, W.
Kay, John Cunliff. Fairfield Hall, near Skipton.
*Kay, John Robinson. Walmersley House, Bury, Lancashire.
Kay, Robert. Haugh Bank, Bolton-le-Moors.
1847. *Kay, Rev. William, D.D. Great Leghs Rectory, Chelmsford.
1872. ‡Keames, William M. 5 Lower Rock-gardens, Brighton.
1875. ‡Keeling, George William. Tuthill, Lydney.
1866. ‡*Keene, Alfred. Eastnoor House, Leamington.*
1878. *Kelland, William Henry. 110 Jermyn-street, London, S.W.; and Grettans, Bow, North Devon.
1876. ‡Kelly, Andrew G. The Manse, Alloa, N.B.
1864. *Kelly, W. M., M.D. 11 The Crescent, Taunton, Somerset.
1853. ‡Kemp, Rev. Henry William, B.A. The Charter House, Hull.
1875. ‡Kennedy, Alexander B. W., C.E., Professor of Engineering in University College, London. 9 Bartholomew-road, London, N.W.
1876. ‡Kennedy, Hugh. Redclyffe, Partickhill, Glasgow.
1857. ‡*Kennedy, Lieut.-Colonel John Pitt.* 20 *Torrington-square, Bloomsbury, London, W.C.*

Year of Election.

1865. ‡*Kenrick, William. Norfolk-road, Edgbaston, Birmingham.*
Kent, J. C. Levant Lodge, Earl's Croome, Worcester.
1857. ‡Kent, William T., M.R.D.S. 51 Rutland-square, Dublin.
1857. ‡*Kenworth, James Ryley. 7 Pembroke-place, Liverpool.*
1857. *Ker, André Allen Murray. Newbliss House, Newbliss, Ireland.
1855. *Ker, Robert. Dougalston, Milngavie, N.B.
1876. ‡Ker, William. 1 Windsor-terrace West, Glasgow.
1868. ‡Kerrison, Roger. Crown Bank, Norwich.
1869. *Kesselmeyer, Charles A. 1 Peter-street, Manchester.
1869. *Kesselmeyer, William Johannes. 1 Peter-street, Manchester.
1861. *Keymer, John. Parker-street, Manchester.
1876. ‡Kidston, J. B. West Regent-street, Glasgow.
1876. ‡Kidston, William. Ferniegair, Helensburgh, N.B.
1865. *Kinahan, Edward Hudson, M.R.I.A. 11 Merrion-square North, Dublin.
1878. §§Kinahan, Edward Hudson, jun. 11 Merrion-square North, Dublin.
1860. ‡Kinahan, G. Henry, M.R.I.A., Geological Survey of Ireland. 14 Hume-street, Dublin.
1858. ‡*Kincaid, Henry Ellis, M.A. 8 Lyddon-terrace, Leeds.*
1875. *Kinch, Edward, F.C.S. Agricultural College, Home Department, Tokio, Japan. (Care of C. J. Kinch, Esq., Eaton Hasting, Lechlade, Gloucestershire.)
1872. *King, Mrs. E. M. 34 Cornwall-road, Westbourne Park, London, W.
1875. *King, F. Ambrose. Avonside, Clifton, Bristol.
1871. *King, Herbert Poole. Theological College, Salisbury.
1855. ‡King, James. Levernholme, Hurlet, Glasgow.
1870. §§King, John Thomson, C.E. 4 Clayton-square, Liverpool.
King, Joseph. Blundell Sands, Liverpool.
1864. §King, Kelburne, M.D. 27 George-street, and Royal Institution, Hull.
1860. *King, Mervyn Kersteman. 16 Vyvyan-terrace, Clifton, Bristol.
1875. *King, Percy L. Avonside, Clifton, Bristol.
1870. ‡King, William. 13 Adelaide-terrace, Waterloo, Liverpool.
King, William Poole, F.G.S. Avonside, Clifton, Bristol.
1869. ‡Kingdon, K. Taddiford, Exeter.
1861. ‡Kingsley, John. Ashfield, Victoria Park, Manchester.
1876. §Kingston, Thomas. Strawberry House, Chiswick, Middlesex.
1835. Kingstone, A. John, M.A. Mosstown, Longford, Ireland.
1875. §Kingzett, Charles T., F.C.S. 12 Auriol-road, The Cedars, West Kensington, London, W.
1867. ‡Kinloch, Colonel. Kirriemuir, Logie, Scotland.
1867. *Kinnaird, The Right Hon. Lord. 2 Pall Mall East, London, S.W.; and Rossie Priory, Inchture, Perthshire.
1870. ‡Kinsman, William R. Branch Bank of England, Liverpool.
1863. ‡Kirkaldy, David. 28 Bartholomew-road North, London, N.W.
1860. ‡Kirkman, Rev. Thomas P., M.A., F.R.S. Croft Rectory, near Warrington.
Kirkpatrick, Rev. W. B., D.D. 48 North Great George-street, Dublin.
1876. *Kirkwood, Anderson, LL.D., F.R.S.E. 12 Windsor-terrace West, Hillhead, Glasgow.
1875. ‡Kirsop, John. 6 Queen's-crescent, Glasgow.
1870. ‡Kitchener, Frank E. Rugby.
1869. ‡Knapman, Edward. The Vineyard, Castle-street, Exeter.
1870. §§Kneeshaw, Henry. 2 Gambier-terrace, Liverpool.
1836. Knipe, J. A. Botcherby, Carlisle.

Year of Election.

1872. *Knott, George, LL.B., F.R.A.S. Cuckfield, Hayward's Heath, Sussex.
1873. *Knowles, George. Moorhead, Shipley, Yorkshire.
1872. ‡Knowles, James. The Hollies, Clapham Common, S.W.
1842. Knowles, John. The Lawn, Rugby.
1870. ‡Knowles, Rev. J. L. 103 Earl's Court-road, Kensington, London, W.
1874. §Knowles, William James. Cullybackey, Belfast, Ireland.
1876. ‡Knox, David N., M.A., M.B. 8 Belgrave Terrace, Hillhead, Glasgow.
*Knox, George James. 2 Coleshill-street, Eaton-square, London, S.W.
1835. Knox, Thomas Perry. Union Club, Trafalgar-square, London, W.C.
1875. *Knubley, Rev. E. P. Staveley Rectory, Boroughbridge, Yorkshire.
1870. ‡Kynaston, Josiah W. St. Helen's, Lancashire.
1865. ‡Kynnersley, J. C. S. The Leveretts, Handsworth, Birmingham.

1858. §Lace, Francis John. Stone Gapp, Cross-hill, Leeds.
1859. §Ladd, William, F.R.A.S. 11 & 13 Beak-street, Regent-street, London, W.
1870. ‡Laird, H. H. Birkenhead.
1870.§§Laird, John, jun. Grosvenor-road, Claughton, Birkenhead.
1877.§§Lake, W. C., M.D. Teignmouth.
1859. ‡Lalor, John Joseph, M.R.I.A. 2 Longford-terrace, Monkstown, Co. Dublin.
1846. *Laming, Richard. The Parade, Arundel, Sussex.
1870. ‡*Lamport, Charles. Upper Norwood, Surrey, S.E.*
1871. ‡Lancaster, Edward. Karesforth Hall, Barnsley, Yorkshire.
1877. ‡Landon, Frederic George, M.A., F.R.A.S. 8 The Circus, Greenwich, London, S.E.
1859. ‡Lang, Rev. John Marshall. Bank House, Morningside, Edinburgh.
1864.§§Lang, Robert. Langford Lodge, College-road, Clifton, Bristol.
1870. ‡Langton, Charles. Barkhill, Aigburth, Liverpool.
*Langton, William. Docklands, Ingatestone, Essex.
1865. ‡Lankester, E. Ray, M.A., F.R.S., Professor of Comparative Anatomy and Zoology in University College, London. Exeter College, Oxford; and 11 Wellington Mansions, North Bank, London, N.W.
Lanyon, Sir Charles. The Abbey, White Abbey, Belfast.
1878.§§Lapper, E., M.D. 61 Harcourt-street, Dublin.
*Larcom, Major-General Sir Thomas Aiskew, Bart., K.C.B., R.E., F.R.S., M.R.I.A. Heathfield House, Fareham, Hants.
Lassell, William, LL.D., F.R.S.L. & E., F.R.A.S. Ray Lodge, Maidenhead.
1861. *Latham, Arthur G. Lower King-street, Manchester.
1870. *Latham, Baldwin, C.E., F.G.S. 7 Westminster-chambers, Westminster, S.W.
1870. ‡Laughton, John Knox, M.A., F.R.A.S., F.R.G.S. Royal Naval College, Greenwich, S.E.
1875. ‡Lavington, William F. 107 Pembroke-road, Clifton, Bristol.
1870. *Law, Channell. 5 Champion-park, Camberwell, London, S.E.
1878.§§Law, Henry, C.E. 5 Queen Anne's-gate, London, S.W.
1857. ‡Law, Hugh, Q.C. 4 Great Denmark-street, Dublin.
1862. ‡Law, Rev. James Edmund, M.A. Little Shelford, Cambridgeshire.
Lawley, The Hon. Francis Charles. Escrick Park, near York.
Lawley, The Hon. Stephen Willoughby. Escrick Park, near York.
1870. ‡Lawrence, Edward. Aigburth, Liverpool.

Year of Election.

1875. ‡Lawson, George, Ph.D., LL.D., Professor of Chemistry and Botany. Halifax, Nova Scotia.
1869. ‡*Lawson, Henry.* 8 *Nottingham-place, London, W.*
1857. ‡Lawson, The Right Hon. James A., LL.D., M.R.I.A. 27 Fitzwilliam-street, Dublin.
1876. ‡*Lawson, John. Cluny Hill, Forres, N.B.*
1868. *Lawson, M. Alexander, M.A., F.L.S., Professor of Botany in the University of Oxford. Botanic Gardens, Oxford.
1863. ‡Lawton, Benjamin C. Neville Chambers, 44 Westgate-street, Newcastle-upon-Tyne.
1853. ‡Lawton, William. 5 Victoria-terrace, Derringham, Hull.
1865. ‡Lea, Henry. 35 Paradise-street, Birmingham.
1857. ‡Leach, Captain R. E. Mountjoy, Phœnix Park, Dublin.
1870. *Leaf, Charles John, F.L.S., F.G.S., F.S.A. Old Change, London, E.C.; and Painshill, Cobham.
1847. *Leatham, Edward Aldam, M.P. Whitley Hall, Huddersfield; and 46 Eaton-square, London, S.W.
1844. *Leather, John Towlerton, F.S.A. Leventhorpe Hall, near Leeds.
1858. ‡Leather, John W. Newton-green, Leeds.
1863. ‡Leavers, J. W. The Park, Nottingham.
1872. ‡Lebour, G. A., F.G.S., Professor of Geology in the College of Physical Science, Newcastle-on-Tyne. Weedpark House, Dipton, Lintz Green, Co. Durham.
1858. *Le Cappelain, John. Wood-lane, Highgate, London, N.
1858. ‡Ledgard, William. Potter Newton, near Leeds.
1861. ‡Lee, Henry. Irwell House, Lower Broughton, Manchester.
1853. *Lee, John Edward, F.G.S., F.S.A. Villa Syracusa, Torquay.
1859. ‡Lees, William. Link Vale Lodge, Viewforth, Edinburgh.
*Leese, Joseph. Glenfield, Altrincham, Manchester.
*Leeson, Henry B., M.A., M.D., F.R.S., F.C.S. The Maples, Bonchurch, Isle of Wight.
1872. ‡Lefevre, G. Shaw, M.P., F.R.G.S. 18 Spring-gardens, London, S.W.
*Lefroy, Lieut.-General Sir John Henry, C.B., K.C.M.G., R.A., F.R.S., F.R.G.S. 82 Queen's-gate, London, S.W.
*Legh, Lieut.-Colonel George Cornwall, M.P. High Legh Hall, Cheshire; and 43 Curzon-street, Mayfair, London, W.
1869. ‡Le Grice, A. J. Trereife, Penzance.
1868. ‡Leicester, The Right Hon. the Earl of. Holkham, Norfolk.
1856. ‡Leigh, The Right Hon. Lord, D.C.L. 37 Portman-square, London, W.; and Stoneleigh Abbey, Kenilworth.
1861. *Leigh, Henry. Moorfield, Swinton, near Manchester.
1870. ‡Leighton, Andrew. 35 High-park-street, Liverpool.
1867. §§Leishman, James. Gateacre Hall, Liverpool.
1870. ‡Leister, G. F. Gresbourn House, Liverpool.
1859. ‡Leith, Alexander. Glenkindie, Inverkindie, N.B.
1863. *Lendy, Captain Auguste Frederic, F.L.S., F.G.S. Sunbury House, Sunbury, Middlesex.
1867. ‡Leng, John. 'Advertiser' Office, Dundee.
1878. §§Lennon, Rev. Francis. The College, Maynooth, Ireland.
1861. ‡Lennox, A. C. W. 7 Beaufort-gardens, Brompton, London, S.W.
Lentaigne, John, C.B., M.D. Tallaght House, Co. Dublin; and 1 Great Denmark-street, Dublin.
Lentaigne, Joseph. 12 Great Denmark-street, Dublin.
1871. §§Leonard, Hugh, F.G.S., M.R.I.A., F.R.G.S.I. Geological Survey of Ireland, 14 Hume-street, Dublin.
1874. ‡Lepper, Charles W. Laurel Lodge, Belfast.

Year of Election.

1861. ‡Leppoc, Henry Julius. Kersal Crag, near Manchester.
1872. ‡Lermit, Rev. Dr. School House, Dedham.
1871. ‡Leslie, Alexander, C.E. 72 George-street, Edinburgh.
1856. ‡Leslie, Colonel J. Forbes. Rothienorman, Aberdeenshire.
1852. ‡Leslie, T. E. Cliffe, LL.B., Professor of Jurisprudence and Political Economy in Queen's College, Belfast.
1876. ‡*Leveson, Edward John. Cluny, Sydenham Hill, S.E.*
1866. §Levi, Dr. Leone, F.S.A., F.S.S., F.R.G.S., Professor of Commercial Law in King's College, London. 5 Crown Office-row, Temple, London, E.C.
1879. §Lewin, Lieut.-Colonel. Tanhurst, Dorking.
1870. ‡Lewis, Alfred Lionel. 151 Church-road, De Beauvoir Town, London, N.
1853. ‡Liddell, George William Moore. Sutton House, near Hull.
1860. ‡Liddell, The Very Rev. H. G., D.D., Dean of Christ Church, Oxford
1876. ‡Lietke, J. O. 30 Gordon-street, Glasgow.
1862. ‡Lilford, The Right Hon. Lord, F.L.S. Lilford Hall, Oundle, Northamptonshire.
*Limerick, The Right Rev. Charles Graves, D.D., M.R.I.A., Lord Bishop of. The Palace, Henry-street, Limerick.
1878.§§Lincolne, William. Ely, Cambridgeshire.
*Lindsay, Charles. Ridge Park, Lanark, N.B.
1871. *Lindsay, The Right Hon. Lord, M.P., F.R.S. 47 Brook-street, London, W.
1870. ‡Lindsay, Thomas, F.C.S. 288 Renfrew-street, Glasgow.
1871. ‡Lindsay, Rev. T. M., M.A., D.D. Free Church College, Glasgow.
1842. *Lingard, John R., F.G.S. 12 Booth-street, Piccadilly, Manchester.
Lingwood, Robert M., M.A., F.L.S., F.G.S. 1 Derby-villas, Cheltenham.
1876. §Linn, James. Geological Survey Office, India-buildings, Edinburgh.
Lister, James. Liverpool Union Bank, Liverpool.
1873. **Lister, Samuel Cunliffe. Farfield Hall, Addingham, Leeds.*
1870. §Lister, Thomas. Victoria-crescent, Barnsley, Yorkshire.
1876. ‡Little, Thomas Evelyn. 42 Brunswick-street, Dublin.
Littledale, Harold. Liscard Hall, Cheshire.
1861. *Liveing, G. D., M.A., F.R.S., F.C.S., Professor of Chemistry in the University of Cambridge. Cambridge.
1876. *Liversidge, Archibald, F.C.S., F.G.S., F.R.G.S., Professor of Geology and Mineralogy in the University of Sydney, N. S.W. (Care of Messrs. Trübner & Co., Ludgate Hill, London, E.C.)
1864.§§Livesay, J. G. Cromarty House, Ventnor, Isle of Wight.
1860. ‡*Livingstone, Rev. Thomas Gott, Minor Canon of Carlisle Cathedral.*
Lloyd, Rev. A. R. Hengold, near Oswestry.
Lloyd, Rev. C., M.A. Whittington, Oswestry.
1842. Lloyd, Edward. King-street, Manchester.
1865. ‡Lloyd, G. B. Edgbaston-grove, Birmingham.
*Lloyd, George, M.D., F.G.S. Park Glass Works, Birmingham.
*Lloyd, Rev. Humphrey, D.D., LL.D., F.R.S. L. & E., M.R.I.A., Provost of Trinity College, Dublin.
1870. ‡*Lloyd, James.* 16 *Welfield-place, Liverpool.*
1870. ‡*Lloyd, J. H., M.D. Anglesey, North Wales.*
1865. ‡Lloyd, John. Queen's College, Birmingham.
Lloyd, Rev. Rees Lewis. Belper, Derbyshire.
1877. *Lloyd, Sampson Samuel, M.P. Moor Hall, Sutton Coldfield.
1865. *Lloyd, Wilson, F.R.G.S. Myrod House, Wednesbury.
1854. *Lobley, James Logan, F.G.S., F.R.G.S. 59 Clarendon-road, Kensington Park, London, W.

Year of Election.

1853. *Locke, John. 133 Leinster-road, Dublin.
1867. *Locke, John. 83 Addison-road, Kensington, London, W.
1872. ‡Locke, John, M.P. 63 Eaton-place, London, S.W.
1863. ‡Lockyer, J. Norman, F.R.S., F.R.A.S. 16 Penywern-road, South Kensington, London, S.W.
1875. *Lodge, Oliver J., D.Sc. University College, London, W.C.; and 17 Parkhurst-road, London, N.
1868. ‡Login, Thomas, C.E., F.R.S.E. India.
1862. ‡Long, Andrew, M.A. King's College, Cambridge.
1876. ‡Long, H. A. Charlotte-street, Glasgow.
1872. ‡Long, Jeremiah. 50 Marine Parade, Brighton.
1871. *Long, John Jex. 727 Duke-street, Glasgow.
1851. ‡Long, William, F.G.S. Hurts Hall, Saxmundham, Suffolk.
1866. §§Longdon, Frederick. Osmaston-road, Derby.
Longfield, The Right Hon. Mountifort, LL.D., M.R.I.A., Regius Professor of Feudal and English Law in the University of Dublin. 47 Fitzwilliam-square, Dublin.
1859. ‡Longmuir, Rev. John, M.A., LL.D. 14 Silver-street, Aberdeen.
1875. *Longstaff, George Blundell, M.A., M.B., F.C.S. Southfield Grange, Wandsworth, S.W.
1871. §Longstaff, George Dixon, M.D., F.C.S. Southfields, Wandsworth, S.W.; and 9 Upper Thames-street, London, E.C.
1872. *Longstaff, Lieut.-Colonel Llewellyn Wood, F.R.G.S. Reform Club, Pall Mall, London, S.W.
1875. §Lonsdale, N. Lowenthal. 4 Aberdeen-terrace, Clifton, Bristol.
1861. *Lord, Edward. Adamroyd, Todmorden.
1863. ‡Losh, W. S. Wreay Syke, Carlisle.
1876. *Love, James, F.R.A.S. Talbot Lodge, Bickerton-road, Upper Holloway, London, N.
1875. *Lovett, W. J. 96 Lionel-street, Birmingham.
1867. *Low, James F. Monifieth, by Dundee.
1863. *Lowe, Lieut.-Colonel Arthur S. H., F.R.A.S. 76 Lancaster-gate, London, W.
1861. *Lowe, Edward Joseph, F.R.S., F.R.A.S., F.L.S., F.G.S., F.M.S. Highfield House Observatory, near Nottingham.
1870. ‡Lowe, G. C. 67 Cecil-street, Greenheys, Manchester.
1868. ‡Lowe, John, M.D. King's Lynn.
1850. ‡Lowe, William Henry, M.D., F.R.S.E. Balgreen, Slateford, Edinburgh.
1853. *Lubbock, Sir John, Bart., M.P., D.C.L., LL.D., F.R.S., F.L.S., F.G.S. High Elms, Farnborough, Kent.
1870. ‡Lubbock, Montague. High Elms, Farnborough, Kent.
1878. §§Lucas, Joseph. Tooting Graveney, London, S.W.
1849. *Luckcock, Howard. Oak-hill, Edgbaston, Birmingham.
1875. §§Lucy, W. C., F.G.S. The Winstones, Brookthorpe, Gloucester.
1867. *Luis, John Henry. Cidhmore, Dundee.
1873. ‡Lumley, J. Hope Villa, Thornbury, near Bradford, Yorkshire.
1866. *Lund, Charles. 48 Market-street, Bradford, Yorkshire.
1873. ‡Lund, Joseph. Ilkley, Yorkshire.
1850. *Lundie, Cornelius. Teviot Bank, Newport Road, Cardiff.
1853. ‡Lunn, William Joseph, M.D. 23 Charlotte-street, Hull.
1858. *Lupton, Arthur. Headingley, near Leeds.
1864. *Lupton, Darnton. The Harehills, near Leeds.
1874. *Lupton, Sydney. Harrow.
1864. *Lutley, John. Brockhampton Park, Worcester.
1866. ‡Lycett, Sir Francis. 18 Highbury-grove, London, N.
1871. ‡*Lyell, Leonard.* 42 *Regent's Park-road, London, N.W.*

Year of Election.

1874. ‡Lynam, James, C.E. Ballinasloe, Ireland.
1857. ‡Lyons, Robert D., M.B., M.R.I.A. 8 Merrion-square West, Dublin.
1878. §§Lyte, Cecil Maxwell. Scientific Club, Savile-row, London, W.
1862. *Lyte, F. Maxwell, F.C.S. Cotford, Oakhill-road, Putney, London, S.W.

1852. ‡McAdam, Robert. 18 College-square East, Belfast.
1854. *Macadam, Stevenson, Ph.D., F.R.S.E., F.C.S., Lecturer on Chemistry. Surgeons' Hall, Edinburgh; and Brighton House, Portobello, by Edinburgh.
1876. ‡M'Adam, William. 30 St. Vincent-crescent, Glasgow.
1876. *Macadam, William Ivison. Surgeons' Hall, Edinburgh.
1868. ‡Macalister, Alexander, M.D., Professor of Zoology in the University of Dublin. 13 Adelaide-road, Dublin.
1878. §McAlister, Donald, B.A., B.Sc. St. Bartholomew's Hospital, London, E.C.
1868. ‡M'Allan, W. A. Norwich.
1879. §MacAndrew, James J. Lukesland, Ivybridge, Sheffield.
1866. *M'Arthur, A., M.P. Raleigh Hall, Brixton Rise, London, S.W.
1838. Macaulay, Henry. 14 Clifton Bank, Rotherham, Yorkshire.
1840. Macaulay, James A. M., M.D. 22 Cambridge-road, Kilburn, London, N.W.
1871. ‡M'Bain, James, M.D., R.N. Logie Villa, York-road, Trinity, Edinburgh.
*MacBrayne, Robert. Messrs. Black and Wingate, 5 Exchange-square, Glasgow.
1866. ‡M'Callan, Rev. J. F., M.A. Basford, near Nottingham.
1863. ‡M'Calmont, Robert. Gatton Park, Reigate.
1855. ‡M'Cann, Rev. James, D.D., F.G.S. 18 Shaftesbury-terrace, Glasgow.
1876. *M'Clelland, A. S. 4 Crown-gardens, Dowanhill, Glasgow.
1840. M'Clelland, James, F.S.S. 32 Pembridge-square, London, W.
1868. ‡M'Clintock, Rear-Admiral Sir Francis L., R.N., F.R.S., F.R.G.S. United Service Club, Pall Mall, London, S.W.
1872. *M'Clure, J. H. Beaconsfield Club, Pall Mall, London, S.W.
1874. ‡M'Clure, Sir Thomas, Bart. Belmont, Belfast.
1878. *M'Comas, Henry. Homestead, Dundrum, Co. Dublin.
*M'Connel, James. Moore-place, Esher, Surrey.
1859. *M'Connell, David C., F.G.S. 44 Manor-place, Edinburgh.
1858. ‡M'Connell, J. E. Woodlands, Great Missenden.
1876. ‡M'Culloch, Richard. 109 Douglas-street, Blythswood-square, Glasgow.
1871. ‡M'Donald, William. Yokohama, Japan. (Care of R. K. Knevitt, Esq., Sun-court, Cornhill, E.C.)
1878. §§McDonnell, Alexander. St. John's, Island Bridge, Dublin.
MacDonnell, Hercules H. G. 2 Kildare-place, Dublin.
1878. §§McDonnell, James. 32 Upper Fitzwilliam-street, Dublin.
1878. §§McDonnell, Robert, M.D., F.R.S., M.R.I.A. 14 Lower Pembroke-street, Dublin.
*M'Ewan, John. 9 Melville-terrace, Stirling, N.B.
1859. ‡Macfarlane, Alexander. 73 Bon Accord-street, Aberdeen.
1871. ‡M'Farlane, Donald. The College Laboratory, Glasgow.
1855. *Macfarlane, Walter. 22 Park-circus, Glasgow.
1879. §Macfarlane, Walter, jun. 22 Park-circus, Glasgow.
1854. *Macfie, Robert Andrew. Dreghorn, Colinton, Edinburgh.
1867. *M'Gavin, Robert. Ballumbie, Dundee.
1855. ‡MacGeorge, Andrew, jun. 21 St. Vincent-place, Glasgow.
1872. ‡M'George, Mungo. Nithsdale, Laurie Park, Sydenham, S.E.

Year of Election.

1873. ‡McGowen, William Thomas. Oak-avenue, Oak Mount, Bradford, Yorkshire.
1855. ‡M'Gregor, Alexander Bennett. 19 Woodside-crescent, Glasgow.
1855. ‡MacGregor, James Watt. 2 Laurence-place, Partick, Glasgow.
1876. ‡M'Grigor, Alexander B. 19 Woodside-terrace, Glasgow.
1859. ‡M'Hardy, David. 54 Netherkinkgate, Aberdeen.
1874. §§MacIlwaine, Rev. Canon, D.D., M.R.I.A. Ulsterville, Belfast.
1876. ‡Macindoe, Patrick. 9 Somerset-place, Glasgow.
1859. ‡Macintosh, John. Middlefield House, Woodside, Aberdeen.
1867. *M'Intosh, W. C., M.D., F R.S. L. & E., F.L.S. Murthly, Perthshire.
1854. *MacIver, Charles. 8 Abercromby-square, Liverpool.
1871. ‡Mackay, Rev. A., LL.D., F.R.G.S. 2 Hatton-place, Grange, Edinburgh.
1873. ‡McKendrick, John G., M.D., F.R.S.E. 2 Chester-street, Edinburgh.
1865. ‡Mackeson, Henry B., F.G.S. Hythe, Kent.
1872. *Mackey, J. A. 24 Buckingham-place, Brighton.
1867. §Mackie, Samuel Joseph, C.E., F.G.S. 22 Eldon-road, Kensington, London, W.
*Mackinlay, David. Great Western-terrace, Hillhead, Glasgow.
1865. ‡Mackintosh, Daniel, F.G.S. 36 Derby-road, Higher Tranmere, Birkenhead.
1850. ‡Macknight, Alexander. 12 London-street, Edinburgh.
1867. ‡Mackson, H. G. 25 Cliff-road, Woodhouse, Leeds.
1872. *McLachlan, Robert, F.R.S., F.L.S. 39 Limes-grove, Lewisham, S.E.
1873. ‡McLandsborough, John, C.E., F.R.A.S., F.G.S. South Park Villa, Harrogate, Yorkshire.
1860. ‡Maclaren, Archibald. Summertown, Oxfordshire.
1864. ‡MacLaren, Duncan, M.P. Newington House, Edinburgh.
1873. ‡MacLaren, Walter S. B. Newington House, Edinburgh.
1876. ‡M'Lean, Charles. 6 Claremont-terrace, Glasgow.
1876. ‡M'Lean, Mrs. Charles. 6 Claremont-terrace, Glasgow.
1862. ‡Macleod, Henry Dunning. 17 Gloucester-terrace, Campden-hill-road, London, W.
1868. §M'Leod, Herbert, F.C.S. Indian Civil Engineering College, Cooper's Hill, Egham.
1875. ‡Macliver, D. 1 Broad-street, Bristol.
1875. ‡Macliver, P. S. 1 Broad-street, Bristol.
1861. *Maclure, John William. 2 Bond-street, Manchester.
1878. *M'Master, George, M.A., J.P. Donnybrook, Ireland.
1862. ‡Macmillan, Alexander. Streatham-lane, Upper Tooting, Surrey, S.W.
1874. ‡MacMordie, Hans, M.A. 8 Donegall-street, Belfast.
1871. ‡M'Nab, William Ramsay, M.D., Professor of Botany in the Royal College of Science, Dublin. 4 Vernon-parade, Clontarf, Dublin.
1870. ‡Macnaught, John, M.D. 74 Huskisson-street, Liverpool.
1867. §M'Neill, John. Balhousie House, Perth.
MacNeill, The Right Hon. Sir John, G.C.B., F.R.S.E., F.R.G.S. Granton House, Edinburgh.
MacNeill, Sir John, LL.D., F.R.S., F.R.A.S., M.R.I.A. 17 The Grove, South Kensington, London, S.W.
1878. §§Macnie, George. 59 Bolton-street, Dublin.
1852. *Macrory, Adam John. Duncairn, Belfast.
*Macrory, Edmund, M.A. 40 Leinster-square, Bayswater, London, W.
1876. *Mactear, James. 16 Burnbank-gardens, Glasgow.
1855. ‡Macvicar, Rev. John Gibson, D.D., LL.D. Moffat, N.B.
1868. ‡Magnay, F. A. Drayton, near Norwich.
1875. *Magnus, Philip. 48 Gloucester-place, Portman-square, London, W.

Year of Election.

1879. §Mahomed, F. A. 13 St. Thomas-street, London, S.E.
1878.§§Mahony, W. A. 34 College-green, Dublin.
1869. ‡Main, Robert. Admiralty, Whitehall, London, S.W.
1866. ‡Major, Richard Henry, F.S.A., Sec.R.G.S. British Museum, London, W.C.
*Malahide, The Right Hon. Lord Talbot de, M.A., D.C.L., F.R.S., F.G.S., F.S.A., M.R.I.A. Malahide Castle, Co. Dublin.
*Malcolm, Frederick. Morden College, Blackheath, London, S.E.
1870. *Malcolm, Sir James, Bart. 1 Cornwall-gardens, South Kensington, London, S.W.
1874. ‡Malcolmson, A. B. Friends' Institute, Belfast.
1863. ‡Maling, C. T. Lovaine-crescent, Newcastle-on-Tyne.
1857. ‡Mallet, John William, Ph.D., M.D., F.R.S., F.C.S., Professor of Chemistry in the University of Virginia, U.S.
*Mallet, Robert, Ph.D., F.R.S., F.G.S., M.R.I.A. Enmore, The Grove, Clapham-road, Clapham, S.W.
1846. ‡Manby, Charles, F.R.S., F.G.S. 60 Westbourne-terrace, Hyde Park, London, W.
1870. ‡Manifold, W. H. 45 Rodney-street, Liverpool.
1866. §Mann, Robert James, M.D., F.R.A.S. 5 Kingsdown-villas, Wandsworth Common, S.W.
Manning, His Eminence Cardinal. Archbishop's House, Westminster, S.W.
1866. ‡Manning, John. Waverley-street, Nottingham.
1878.§§Manning, Robert. 4 Upper Ely-place, Dublin.
1864. ‡Mansel, J. C. Long Thorns, Blandford.
1870. ‡Marcoartu, Senor Don Arturo de. Madrid.
1864. ‡Markham, Clements R., C.B., F.R.S., F.L.S., Sec.R.G.S., F.S.A. 21 Eccleston-square, Pimlico, London, S.W.
1863. ‡Marley, John. Mining Office, Darlington.
*Marling, Samuel S., M.P. Stanley Park, Stroud, Gloucestershire.
1871. ‡Marreco, A. Friere-. College of Physical Science, Newcastle-on-Tyne.
1857. ‡Marriott, William, F.C.S. Grafton-street, Huddersfield.
1842. Marsden, Richard. Norfolk-street, Manchester.
1870. ‡Marsh, John. Rann Lea, Rainhill, Liverpool.
1865. ‡Marsh, J. F. Hardwick House, Chepstow.
1864. ‡Marsh, Thomas Edward Miller. 37 Grosvenor-place, Bath.
1852. ‡Marshall, James D. Holywood, Belfast.
1876. ‡Marshall, Peter. 6 Parkgrove-terrace, Glasgow.
1858. ‡Marshall, Reginald Dykes. Adel, near Leeds.
1849. *Marshall, William P. 247 Monument-road, Birmingham.
1865. §Marten, Edward Bindon. Pedmore, near Stourbridge.
1848. ‡Martin, Henry D. 4 Imperial-circus, Cheltenham.
1878.§§Martin, H. Newell. Christ's College, Cambridge.
1871. ‡Martin, Rev. Hugh, M.A. Greenhill Cottage, Lasswade, by Edinburgh.
1870. ‡*Martin, Robert, M.D.* 120 *Upper Brook-street, Manchester.*
1836. Martin, Studley. 177 Bedford-street South, Liverpool.
*Martindale, Nicholas. Meadow Bank, Vanbrugh-fields, Blackheath, S.E.
*Martineau, Rev. James, LL.D., D.D. 5 Gordon-street, Gordon-square, London, W.C.
1865. ‡Martineau, R. F. Highfield-road, Edgbaston, Birmingham.
1865. ‡Martineau, Thomas. 7 Cannon-street, Birmingham.
1875. ‡Martyn, Samuel, M.D. 8 Buckingham-villas, Clifton, Bristol.

Year of Election.

1878. §Masaki, Taiso. Japanese Consulate, 84 Bishopsgate-street Within, London, E.C.
1847. ‡Maskelyne, Nevil Story, M.A., F.R.S., F.G.S., Keeper of the Mineralogical Department, British Museum, and Professor of Mineralogy in the University of Oxford. 112 Gloucester-terrace, Hyde Park-gardens, London, W.
1861. *Mason, Hugh. Groby Lodge, Ashton-under-Lyne.
1879. §Mason, James, M.D. Montgomery House, Sheffield.
1868. ‡Mason, James Wood, F.G.S. The Indian Museum, Calcutta. (Care of Messrs. Henry S. King & Co., 65 Cornhill, London, E.C.)
1876. §§Mason, Robert. 6 Albion-crescent, Dowanhill, Glasgow.
1876. ‡Mason, Stephen. 9 Rosslyn-terrace, Hillhead, Glasgow.
Massey, Hugh, Lord. Hermitage, Castleconnel, Co. Limerick.
1870. ‡*Massey, Thomas.* 5 *Gray's-Inn-square, London, W.C.*
1870. ‡Massy, Frederick. 50 Grove-street, Liverpool.
1876. ‡Matheson, John. Eastfield, Rutherglen, Glasgow.
1865. *Mathews, G. S. 32 Augustus-road, Edgbaston, Birmingham.
1861. *Mathews, William, M.A., F.G.S. 49 Harborne-road, Birmingham.
1876. *Mathiesen, John, jun. Cordale, Renton, Glasgow.
1865. ‡Matthews, C. E. Waterloo-street, Birmingham.
1858. ‡Matthews, F. C. Mandre Works, Driffield, Yorkshire.
1860. ‡Matthews, Rev. Richard Brown. Shalford Vicarage, near Guildford.
1863. ‡Maughan, Rev. W. Benwell Parsonage, Newcastle-on-Tyne.
1865. *Maw, George, F.L.S., F.G.S., F.S.A. Benthall Hall, Broseley, Shropshire.
1876. ‡Maxton, John. 6 Belgrave-terrace, Glasgow.
1864. *Maxwell, Francis. St. Germains, Longniddry, East Lothian.
*Maxwell, James Clerk, M.A., LL.D., F.R.S. L. & E., Professor of Experimental Physics in the University of Cambridge. Glenlair, Dalbeattie, N.B.; and 11 Scroope-terrace, Cambridge.
*Maxwell, Robert Perceval. Groomsport House, Belfast.
1868. ‡Mayall, J. E., F.C.S. Stork's Nest, Lancing, Sussex.
1835. Mayne, Edward Ellis. Rocklands, Stillorgan, Ireland.
1878. *Mayne, Thomas. 33 Castle-street, Dublin.
1863. ‡Mease, George D. Bylton Villa, South Shields.
1871. ‡Meikie, James, F.S.S. 6 St. Andrew's-square, Edinburgh.
1879. §Meiklejohn, John W. S., M.D. H.M. Dockyard, Chatham.
1867. ‡Meldrum, Charles, M.A., F.R.S., F.R.A.S. Port Louis, Mauritius.
1879. *Mellish, Henry. Hodsock Priory, Worksop.
1866. ‡Mello, Rev. J. M., M.A., F.G.S. St. Thomas's Rectory, Brampton, Chesterfield.
1854. ‡Melly, Charles Pierre. 11 Rumford-street, Liverpool.
1847. ‡Melville, Professor Alexander Gordon, M.D. Queen's College, Galway.
1863. ‡Melvin, Alexander. 42 Buccleuch-place, Edinburgh.
1877. *Menabrea, Lieut.-General Count. 35 Queen's-gate, London, S.W.
1862. ‡Mennell, Henry J. St. Dunstan's-buildings, Great Tower-street, London, E.C.
1879. §Merivale, John Herman. Nedderton R.S.O., Northumberland.
1879. §Merivale, Walter. Engineers' Office, North-Eastern Railway, Newcastle-on-Tyne.
1868. §Merrifield, Charles W., F.R.S. 20 Girdler's-road, Brook Green, London, W.

Year of Election.

1877. ‡Merrifield, John, Ph.D., F.R.A.S. Gascoigne-place, Plymouth.
1871. ‡*Merson, John. Northumberland County Asylum, Morpeth.*
1872. *Messent, John. 429 Strand, London, W.C.
1863. ‡Messent, P. T. 4 Northumberland-terrace, Tynemouth.
1869. ‡Miall, Louis C., F.G.S., Professor of Biology in Yorkshire College, Leeds.
1865. ‡*Michie, Alexander.* 26 *Austin Friars, London, E.C.*
1865. ‡Middlemore, William. Edgbaston, Birmingham.
1876. *Middleton, Robert T. 197 West George-street, Glasgow.
1866. ‡Midgley, John. Colne, Lancashire.
1867. ‡Midgley, Robert. Colne, Lancashire.
1859. ‡Millar, John, J.P. Lisburn, Ireland.
1863. ‡Millar, John, M.D., F.L.S., F.G.S. Bethnal House, Cambridge-road, London, E.
Millar, Thomas, M.A., LL.D., F.R.S.E. Perth.
1876. ‡Millar, William. Highfield House, Dennistoun, Glasgow.
1876. §§Millar, W. J. 145 Hill-street, Garnethill, Glasgow.
1876. ‡Miller, Daniel. 258 St. George's-road, Glasgow.
1875. ‡Miller, George. Brentry, near Bristol.
1865. ‡Miller, Rev. Canon J. C., D.D. The Vicarage, Greenwich, S.E.
1861. *Miller, Robert. Poise House, Bosden, near Stockport.
1876. *Miller, Robert. 1 Lily Bank-terrace, Hillhead, Glasgow.
1876. ‡Miller, Thomas Paterson. Morriston House, Cambuslang, N.B.
Miller, William Hallows, M.A., LL.D., F.R.S., F.G.S., Professor of Mineralogy in the University of Cambridge. 7 Scroope-terrace, Cambridge.
1868. *Milligan, Joseph, F.L.S., F.G.S., F.R.A.S., F.R.G.S. 6 Craven-street, Strand, London, W.C.
1868. *Mills, Edmund J., D.Sc., F.R.S., F.C.S., Young Professor of Technical Chemistry in Anderson's University, Glasgow. 234 East George-street, Glasgow.
*Mills, John Robert. 11 Bootham, York.
Milne, Admiral Sir Alexander, Bart., G.C.B., F.R.S.E. 13 New-street, Spring-gardens, London, S.W.
1867. ‡Milne, James. Murie House, Errol, by Dundee.
1867. *Milne-Home, David, M.A., F.R.S.E., F.G.S. 10 York-place, Edinburgh.
1864. *Milton, The Right Hon. Lord, F.R.G.S. 17 Grosvenor-street, London, W.; and Wentworth, Yorkshire.
1865. ‡Minton, Samuel, F.G.S. Oakham House, near Dudley.
1855. ‡Mirrlees, James Buchanan. 45 Scotland-street, Glasgow.
1859. ‡Mitchell, Alexander, M.D. Old Rain, Aberdeen.
1876. ‡Mitchell, Andrew. 20 Woodside-place, Glasgow.
1863. ‡Mitchell, C. Walker. Newcastle-on-Tyne.
1873. ‡Mitchell, Henry. Parkfield House, Bradford, Yorkshire.
1870. ‡Mitchell, John. York House, Clitheroe, Lancashire.
1868. ‡Mitchell, John, jun. Pole Park House, Dundee.
1879. §Mivart, St. George, M.D., F.R.S., F.L.S., F.Z.S., Professor of Biology in University College, Kensington. 71 Seymour-street, London, W.
1855. *Moffat, John, C.E. Ardrossan, Scotland.
1854. §§Moffat, Thomas, M.D., F.G.S., F.R.A.S., F.M.S. Hawarden, Chester.
1864. ‡Mogg, John Rees. High Littleton House, near Bristol.
1866. ‡Moggridge, Matthew, F.G.S. 8 Bina-gardens, South Kensington, London, S.W.
1855. ‡Moir, James. 174 Gallogate, Glasgow.

Year of Election.

1861. ‡Molesworth, Rev. W. Nassau, M.A. Spotland, Rochdale.
Mollan, John, M.D. 8 Fitzwilliam-square North, Dublin.
1878. §Molloy, Constantine. 70 Lower Gardiner-street, Dublin.
1877. *Molloy, Rev. Gerald, D.D. 86 Stephen's-green, Dublin.
1852. ‡Molony, William, LL.D. Carrickfergus.
1865. §Molyneux, William, F.G.S. Branston Cottage, Burton-upon-Trent.
1860. ‡Monk, Rev. William, M.A., F.R.A.S. Wymington Rectory, Higham Ferrers, Northamptonshire.
1853. ‡Monroe, Henry, M.D. 10 North-street, Sculcoates, Hull.
1872. §§Montgomery, R. Mortimer. 3 Porchester-place, Edgware-road, London, W.
1872. ‡Moon, W., LL.D. 104 Queen's-road, Brighton.
1859. ‡Moore, Charles, F.G.S. 6 Cambridge-terrace, Bath.
1857. ‡Moore, Rev. John, D.D. Clontarf, Dublin.
Moore, John. 2 Meridian-place, Clifton, Bristol.
*Moore, John Carrick, M.A., F.R.S., F.G.S. 113 Eaton-square, London, S.W.; and Corswall, Wigtonshire.
1866. *Moore, Thomas, F.L.S. Botanic Gardens, Chelsea, London, S.W.
1854. ‡Moore, Thomas John, Cor. M.Z.S. Free Public Museum, Liverpool.
1877. §§Moore, W. F. The Friary, Plymouth.
1857. *Moore, Rev. William Prior. The Royal School, Cavan, Ireland.
1877. ‡Moore, William Vanderkemp. 15 Princess-square, Plymouth.
1871. ‡More, Alexander G., F.L.S., M.R.I.A. 3 Botanic View, Glasnevin, Dublin.
1873. ‡Morgan, Edward Delmar. 15 Rowland-gardens, London, W.
1868. ‡*Morgan, Thomas H. Oakhurst, Hastings.*
1833. Morgan, William, D.C.L. Oxon. Uckfield, Sussex.
1878. §Morgan, William, Ph.D. Swansea.
1867. ‡Morison, William R. Dundee.
1863. ‡Morley, Samuel, M.P. 18 Wood-street, Cheapside, London, E.C.
1865. *Morrieson, Colonel Robert. Oriental Club, Hanover-square, London, W.
*Morris, Rev. Francis Orpen, B.A. Nunburnholme Rectory, Hayton, York.
Morris, Samuel, M.R.D.S. Fortview, Clontarf, near Dublin.
1876. §§Morris, Rev. S. S. O. The Grammar School, Dolgelly.
1874. ‡Morrison, G. J., C.E. 5 Victoria-street, Westminster, S.W.
1871. *Morrison, James Darsie. 27 Grange-road, Edinburgh.
1879. §Morrison, Dr. R. Milner. 13 Douglas-crescent, Edinburgh.
1865. §Mortimer, J. R. St. John's-villas, Driffield.
1869. ‡Mortimer, William. Bedford-circus, Exeter.
1857. §Morton, George H., F.G.S. 122 London-road, Liverpool.
1858. *Morton, Henry Joseph. 4 Royal Crescent, Scarborough.
1871. ‡Morton, Hugh. Belvedere House, Trinity, Edinburgh.
1857. ‡Moses, Marcus. 4 Westmoreland-street, Dublin.
Mosley, Sir Oswald, Bart., D.C.L. Rolleston Hall, Burton-upon-Trent, Staffordshire.
1878. §*Moss, Edward Lawton, M.D., R.N.* 48 *Haddington-road, Dublin.*
Moss, John. Ottersgool, near Liverpool.
1878. *Moss, John Francis. Ranmoor, Sheffield.
1870. ‡Moss, John Miles, M.A. 2 Esplanade, Waterloo, Liverpool.
1876. §§Moss, Richard Jackson, F.C.S., M.R.I.A. 66 Kenilworth-square, Rathgar, Dublin.

Year of Election.

1873. **Mosse, George Staley. Cowley Hall, near Uxbridge.*
1864. *Mosse, J. R. Public Works' Department, Ceylon. (Care of Messrs. H. S. King & Co., 65 Cornhill, London, E.C.)
1873. ‡Mossman, William. Woodhall, Calverley, Leeds.
1869. §Mott, Albert J., F.G.S. Adsett Court, Westbury-on-Severn.
1865. ‡Mott, Charles Grey. The Park, Birkenhead.
1866. §Mott, Frederick T., F.R.G.S. Birstall Hill, Leicester.
1862. *Mouat, Frederick John, M.D., Local Government Inspector. 12 Durham-villas, Campden Hill, London, W.
1856. ‡Mould, Rev. J. G., B.D. Fulmodeston Rectory, Dereham, Norfolk.
1878. *Moulton, J. F. 74 Onslow-gardens, London, S.W.
1863. ‡Mounsey, Edward. Sunderland.
Mounsey, John. Sunderland.
1861. *Mountcastle, William Robert. Bridge Farm, Ellenbrook, near Manchester.
1877. ‡Mount-Edgcumbe, The Right Hon. the Earl of, D.C.L. Mount-Edgcumbe, Devonport.
Mowbray, James. Combus, Clackmannan, Scotland.
1850. ‡Mowbray, John T. 15 Albany-street, Edinburgh.
1874.§§Muir, M. M. Pattison, F.R.S.E. Owens College, Manchester.
1876. *Muir, John. 6 Park-gardens, Glasgow.
1876.§§Muir, Thomas. High School, Glasgow.
1872. ‡Muirhead, Alexander, D.Sc., F.C.S. 29 Regency-street, Westminster, S.W.
1871. *Muirhead, Henry, M.D. Bushy Hill, Cambuslang, Lanarkshire.
1876. ‡Muirhead, R. F., B.Sc. Meikle Cloak, Lochwinnoch, Renfrewshire.
Munby, Arthur Joseph. 6 Fig-tree-court, Temple, London, E.C.
1866. ‡Mundella, A. J., M.P., F.R.G.S. The Park, Nottingham.
1876. §Munro, Donald, F.C.S. 97 Eglinton-street, Glasgow.
1860. *Munro, Major-General William, C.B., F.L.S. United Service Club, Pall Mall, London, S.W.
1872. *Munster, H. Sillwood Lodge, Brighton.
1871. *Munster, William Felix. 41 Brompton-square, London, W.
1864. ‡Murch, Jerom. Cranwells, Bath.
*Murchison, John Henry. Surbiton Hill, Kingston.
1864. *Murchison, K. R. Brokehurst, East Grinstead.
1876. ‡Murdoch, James. Altony Albany, Girvan, N.B.
1855. ‡Murdock, James B. Hamilton-place, Langside, Glasgow.
1852. ‡Murney, Henry, M.D. 10 Chichester-street, Belfast.
1852. ‡Murphy, Joseph John. Old Forge, Dunmurry, Co. Antrim.
1869. ‡Murray, Adam. 4 Westbourne-crescent, Hyde Park, London, W.
1871. ‡*Murray, Dr. Ivor, F.R.S.E. The Knowle, Brenchley, Staplehurst, Kent.*
Murray, John, F.G.S., F.R.G.S. 50 Albemarle-street, London, W.; and Newsted, Wimbledon, Surrey.
1871.§§Murray, John. 3 Clarendon-crescent, Edinburgh.
1859. ‡Murray, John, M.D. Forres, Scotland.
*Murray, John, C.E. Downlands, Sutton, Surrey.
‡Murray, Rev. John. Morton, near Thornhill, Dumfriesshire.
1872. ‡Murray, J. Jardine. 99 Montpellier-road, Brighton.
1863. ‡Murray, William. 34 Clayton-street, Newcastle-on-Tyne.
1859. *Murton, James. Highfield, Silverdale, Carnforth, Lancaster.
Musgrave, The Venerable Charles, D.D., Archdeacon of Craven, Halifax.
1874. §Musgrave, James, J.P. Drumglass House, Belfast.
1861. ‡Musgrove, John, jun. Bolton.
1870. *Muspratt, Edward Knowles. Seaforth Hall, near Liverpool.
1865. ‡*Myers, Rev. E., F.G.S. 3 Waterloo-road, Wolverhampton.*

Year of Election.

1859. ‡Mylne, Robert William, F.R.S., F.G.S., F.S.A. 21 Whitehall-place, London, S.W.

1842. Nadin, Joseph. Manchester.
1855. *Napier, James R., F.R.S. 22 Blythswood-square, Glasgow.
1876. §§Napier, James S. 9 Woodside-place, Glasgow.
1876. ‡Napier, John. Saughfield House, Hillhead, Glasgow.
*Napier, Captain Johnstone, C.E. Laverstock House, Salisbury.
1839. *Napier, The Right Hon. Sir Joseph, Bart., D.C.L., LL.D. 4 Merrion-square South, Dublin.
Napper, James William L. Loughcrew, Oldcastle, Co. Meath.
1872. §§Nares, Captain Sir G. S., K.C.B., R.N., F.R.S., F.R.G.S. 23 St. Philip's-road, Surbiton.
1866. ‡Nash, Davyd W., F.S.A., F.L.S. 10 Imperial-square, Cheltenham.
1850. *Nasmyth, James. Penshurst, Tunbridge.
1864. ‡Natal, Rev. John William Colenso, D.D., Lord Bishop of. Natal.
1860. ‡Neate, Charles, M.A. Oriel College, Oxford.
1873. ‡Neill, Alexander Renton. Fieldhead House, Bradford, Yorkshire.
1873. ‡Neill, Archibald. Fieldhead House, Bradford, Yorkshire.
1855. ‡Neilson, Walter. 172 West George-street, Glasgow.
1865. ‡Neilson, W. Montgomerie. Glasgow.
1876. ‡Nelson, D. M. 48 Gordon-street, Glasgow.
Ness, John. Helmsley, near York.
1868. ‡Nevill, Rev. H. R. The Close, Norwich.
1866. *Nevill, Rev. Samuel Tarratt, D.D., F.L.S., Bishop of Dunedin, New Zealand.
1857. ‡Neville, John, C.E., M.R.I.A. Roden-place, Dundalk, Ireland.
1852. ‡Neville, Parke, C.E., M.R.I.A. 58 Pembroke-road, Dublin.
1869. ‡Nevins, John Birkbeck, M.D. 3 Abercromby-square, Liverpool.
1842. New, Herbert. Evesham, Worcestershire.
Newall, Henry. Hare Hill, Littleborough, Lancashire.
*Newall, Robert Stirling, F.R.S., F.R.A.S. Ferndene, Gateshead-upon-Tyne.
1879. §Newbould, John. Sharrow Bank, Sheffield.
1866. *Newdigate, Albert L. 25 Craven-street, Charing Cross, London, W.C.
1876. §Newhaus, Albert. 1 Prince's-terrace, Glasgow.
1842. *Newman, Professor Francis William. 15 Arundel-crescent, Weston-super-Mare.
1863. *Newmarch, William, F.R.S. Beech Holme, Balham, London, S.W.
1866. *Newmarch, William Thomas. 1 Elms-road, Clapham Common, London, S.W.
1877. §§Newth, A. H., M.D. Hayward's Heath, Sussex.
1860. *Newton, Alfred, M.A., F.R.S., F.L.S., Professor of Zoology and Comparative Anatomy in the University of Cambridge. Magdalen College, Cambridge.
1872. ‡Newton, Rev. J. 125 Eastern-road, Brighton.
1865. ‡Newton, Thomas Henry Goodwin. Clopton House, near Stratford-on-Avon.
1867. ‡Nicholl, Thomas, ex-Dean of Guild. Dundee.
1875. ‡Nicholls, J. F. City Library, Bristol.
1866. ‡Nicholson, Sir Charles, Bart., M.D., D.C.L., LL.D., F.G.S., F.R.G.S. The Grange, Totteridge, Herts.
1838. *Nicholson, Cornelius, F.G.S., F.S.A. Ashleigh, Ventnor, Isle of Wight.
1861. *Nicholson, Edward. 88 Mosley-street, Manchester.

Year of Election.

1871. §§Nicholson, E. Chambers. Herne Hill, London, S.E.
1867. ‡Nicholson, Henry Alleyne, M.D., D.Sc., F.G.S., Professor of Natural History in the University of St. Andrews, N.B.
1867. ‡Nimmo, Dr. Matthew. Nethergate, Dundee.
1878. §§Niven, C. Queen's College, Cork.
1877. ‡Niven, James, M.A. Queen's College, Cambridge.
Niven, Ninian. Clonturk Lodge, Drumcondra, Dublin.
‡Nixon, Randal C. J., M.A. Green Island, Belfast.
1863. *Noble, Captain Andrew, F.R.S., F.R.A.S., F.C.S. Elswick Works, Newcastle-on-Tyne.
1879. §Noble, T. S., F.G.S. Lendal, York.
1870. ‡Nolan, Joseph, M.R.I.A. 14 Hume-street, Dublin.
1860. *Nolloth, Rear-Admiral Matthew S., R.N., F.R.G.S. United Service Club, S.W.; and 13 North-terrace, Camberwell, London, S.E.
1859. ‡Norfolk, Richard. Messrs. W. Rutherford and Co., 14 Canada Dock, Liverpool.
1868. Norgate, William. Newmarket-road, Norwich.
1863. §§Norman, Rev. Alfred Merle, M.A. Burnmoor Rectory, Fence House, Co. Durham.
Norreys, Sir Denham Jephson, Bart. Mallow Castle, Co. Cork.
1865. ‡Norris Richard, M.D. 2 Walsall-road, Birchfield, Birmingham.
1872. ‡Norris, Thomas George. Corphwysfa, Llanrwst, North Wales.
1866. ‡North, Thomas. Cinder-hill, Nottingham.
1869. ‡Northcote, The Right Hon. Sir Stafford H., Bart., C.B., M.P., F.R.S. Pynes, Exeter.
*Northwick, The Right Hon. Lord, M.A. 7 Park-street, Grosvenor-square, London, W.
1868. ‡Norwich, The Hon. and Right Rev. J. T. Pelham, D.D., Lord Bishop of. Norwich.
1861. ‡Noton, Thomas. Priory House, Oldham.
Nowell, John. Farnley Wood, near Huddersfield.
1878. §§Nugent, Edward, C.E. Seel's-buildings, Liverpool.

1878. §O'Brien, Murrough. 1 Willow-terrace, Blackrock, Co. Dublin.
O'Callaghan, George. Tallas, Co. Clare.
1878. §§O'Carroll, Joseph F. 78 Rathgar-road, Dublin.
1878. §§O'Connor Don, The, M.P. Clonalis, Castlerea, Ireland.
Odgers, Rev. William James. Savile House, Fitzjohn's-avenue, Hampstead, London, N.W.
1858. *Odling, William, M.B., F.R.S., F.C.S., Waynflete Professor of Chemistry in the University of Oxford. The Museum, Oxford.
1857. ‡O'Donnavan, William John. Portarlington, Ireland.
1870. O'Donnell, J. O., M.D. 34 Rodney-street, Liverpool.
1877. §Ogden, Joseph. 46 London-wall, London, E.C.
1876. §§Ogilvie, Campbell P. Sizewell House, Lenton, Suffolk.
1859. ‡Ogilvie, C. W. Norman. Baldovan House, Dundee.
1874. §§Ogilvie, Thomas Robertson. Bank Top, 3 Lyle-street, Greenock, N.B.
*Ogilvie-Forbes, George, M.D., Professor of the Institutes of Medicine in Marischal College, Aberdeen. Boyndlie, Fraserburgh, N.B.
1863. ‡*Ogilvy, G. R. Inverquharity, N.B.*
1863. ‡Ogilvy, Sir John, Bart. Inverquharity, N.B.
*Ogle, William, M.D., M.A. The Elms, Derby.
1859. ‡Ogston, Francis, M.D. 18 Adelphi-court, Aberdeen.
1837. ‡O'Hagan, John, M.A., Q.C. 22 Upper Fitzwilliam-street, Dublin.

Year of Election.

1874. ‡O'Hagan, The Right Hon. Lord, M.R.I.A. 34 Rutland-square West, Dublin.
1862. ‡O'Kelly, Joseph, M.A., M.R.I.A. 14 Hume-street, Dublin.
1853. §Oldham, James, C.E. Cottingham, near Hull.
1860. ‡*O'Leary, Professor Purcell, M.A. Queenstown.*
1863. ‡Oliver, Daniel, F.R.S., Professor of Botany in University College, London. Royal Gardens, Kew, Surrey.
1874. ‡O'Meara, Rev. Eugene. Newcastle Rectory, Hazlehatch, Ireland.
*Ommanney, Admiral Sir Erasmus, C.B., F.R.S., F.R.A.S., F.R.G.S. The Towers, Yarmouth, Isle of Wight.
1872. ‡Onslow, D. Robert. New University Club, St. James's, London, S.W.
1867. ‡Orchar, James G. 9 William-street, Forebank, Dundee.
1842. Ormerod, George Wareing, M.A., F.G.S. Brookbank, Teignmouth.
1861. ‡Ormerod, Henry Mere. Clarence-street, Manchester; and 11 Woodland-terrace, Cheetham Hill, Manchester.
1858. ‡Ormerod, T. T. Brighouse, near Halifax.
1835. Orpen, John H., LL.D., M.R.I.A. 58 Stephen's-green, Dublin.
1838. Orr, Alexander Smith. 57 Upper Sackville-street, Dublin.
1876. ‡*Orr, John B. Granville-terrace, Crosshill, Glasgow.*
1873. ‡Osborn, George. 47 Kingscross-street, Halifax.
1865. ‡Osborne, E. C. Carpenter-road, Edgbaston, Birmingham.
*Osler, A. Follett, F.R.S. South Bank, Edgbaston, Birmingham.
1877. *Osler, Miss A. F. South Bank, Edgbaston, Birmingham.
1865. *Osler, Henry F. 50 Carpenter-road, Edgbaston, Birmingham.
1869. *Osler, Sidney F. 1 Pownall-gardens, Hounslow, near London.
1854. ‡Outram, Thomas. Greetland, near Halifax.
Overstone, Samuel Jones Lloyd, Lord, F.G.S. 2 Carlton-gardens, London, S.W.; and Wickham Park, Bromley.
1870. ‡Owen, Harold. The Brook Villa, Liverpool.
1857. ‡Owen, James H. Park House, Sandymount, Co. Dublin.
Owen, Richard, C.B., M.D., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., Hon. M.R.S.E., Director of the Natural-History Department, British Museum. Sheen Lodge, Mortlake, Surrey, S.W.
1877. ‡Oxland, Dr. Robert, F.C.S. 8 Portland-square, Plymouth.

1872. *Paget, Joseph. Stuffynwood Hall, Mansfield, Nottingham.
1875. ‡Paine, William Henry, M.D., F.G.S. Stroud, Gloucestershire.
1870. *Palgrave, R. H. Inglis. 11 Britannia-terrace, Great Yarmouth.
1873. ‡Palmer, George. The Acacias, Reading, Berks.
1866.§§Palmer, H. 76 Goldsmith-street, Nottingham.
1878. *Palmer, Joseph Edward. Lucan, Co. Dublin.
1866.§§Palmer, William. Iron Foundry, Canal-street, Nottingham.
1872. *Palmer, W. R. 376 Coldharbour-lane, Stockwell, S.W.
Palmes, Rev. William Lindsay, M.A. Naburn Hall, York.
1857. *Parker, Alexander, M.R.I.A. 59 William-street, Dublin.
1863. ‡Parker, Henry. Low Elswick, Newcastle-on-Tyne.
1863. ‡Parker, Rev. Henry. Idlerton Rectory, Low Elswick, Newcastle-on-Tyne.
1874. ‡Parker, Henry R., LL.D. Methodist College, Belfast.
Parker, Joseph, F.G.S. Upton Chaney, Bitton, near Bristol.
Parker, Richard. Dunscombe, Cork.
1865. *Parker, Walter Mantel. High-street, Alton, Hants.
Parker, Rev. William. Saham, Norfolk.
1853. ‡Parker, William. Thorton-le-Moor, Lincolnshire.
1865. *Parkes, Samuel Hickling. 6 St. Mary's-row, Birmingham.

Year of Election.

1864. ‡PARKES, WILLIAM. 23 Abingdon-street, Westminster, S.W.
1859. ‡Parkinson, Robert, Ph.D. West View, Toller-lane, Bradford, Yorkshire.
1862. *Parnell, John, M.A. 1 The Common, Upper Clapton, London, E.
Parnell, Richard, M.D., F.R.S.E. Gattonside Villa, Melrose, N.B.
1877.§§Parson, T. Edgcumbe. 36 Torrington-place, Plymouth.
1865. *Parsons, Charles Thomas. Norfolk-road, Edgbaston, Birmingham.
1878.§§Parsons, Hon. C. A. 10 Connaught-place, London, W.
1878.§§Parsons, Hon. R. C. 10 Connaught-place, London, W.
1875. ‡Pass, Alfred C. 16 Redland Park, Clifton, Bristol.
1855. ‡*Paterson, William.* 100 *Brunswick-street, Glasgow.*
1861. ‡Patterson, Andrew. Deaf and Dumb School, Old Trafford, Manchester.
1871. *Patterson, A. Henry. 3 Old-buildings, Lincoln's Inn, London, W.C.
1863. ‡Patterson, H. L. Scott's House, near Newcastle-on-Tyne.
1867. ‡Patterson, James. Kinnettles, Dundee.
1876.§§Patterson, T. L. Belmont, Margaret-street, Greenock.
1874. ‡Patterson, W. H., M.R.I.A. 26 High-street, Belfast.
1863. ‡Pattinson, John. 75 The Side, Newcastle-on-Tyne.
1863. ‡Pattinson, William. Felling, near Newcastle-upon-Tyne.
1867. §Pattison, Samuel Rowles, F.G.S. 50 Lombard-street, London, E.C.
1864. ‡Pattison, Dr. T. H. London-street, Edinburgh.
1879. *Patzer, F. R. Stoke-on-Trent.
1863. ‡PAUL, BENJAMIN H., Ph.D. 1 Victoria-street, Westminster, S.W.
1863. ‡PAVY, FREDERICK WILLIAM, M.D., F.R.S., Lecturer on Physiology and Comparative Anatomy and Zoology at Guy's Hospital. 35 Grosvenor-street, London, W.
1864. ‡Payne, Edward Turner. 3 Sydney-place, Bath.
1877.§§Payne, J. C. Charles. Botanic Avenue, Belfast.
1851. ‡*Payne, Joseph.* 4 *Kildare-gardens, Bayswater, London, W.*
1866. ‡*Payne, Dr. Joseph F.* 4 *Kildare-gardens, Bayswater, London, W.*
1876. ‡Peace, G. H. Morton Grange, Eccles, near Manchester.
1879. §Peace, William K. Western Bank, Sheffield.
1847. ‡PEACH, CHARLES W., Pres. R.P.S. Edin., A.L.S. 30 Haddington-place, Leith-walk, Edinburgh.
1875. ‡Peacock, Thomas Francis. 12 South-square, Gray's Inn, London, W.C.
1876. ‡Pearce, W. Elmpark House, Govan, Glasgow.
*Pearsall, Thomas John, F.C.S. Birkbeck Literary and Scientific Institution, Southampton-buildings, Chancery-lane, London, W.C.
1875. ‡*Pearson, H. W. Tramore Villa, Nugent Hill, Cotham, Bristol.*
1872. *Pearson, Joseph. Lern Side Works, Nottingham.
1870. ‡Pearson, Rev. Samuel. 48 Prince's-road, Liverpool.
1863. §Pease, H. F. Brinkburn, Darlington.
1863. *Pease, Joseph W., M.P. Hutton Hall, near Guisborough.
1863. ‡Pease, J. W. Newcastle-on-Tyne.
1858. *Pease, Thomas, F.G.S. Cote Bank, Westbury-on-Trym, near Bristol.
Peckitt, Henry. Carlton Husthwaite, Thirsk, Yorkshire.
1855. *Peckover, Alexander, F.L.S., F.R.G.S. Harecroft House, Wisbech, Cambridgeshire.
*Peckover, Algernon, F.L.S. Sibald's Holme, Wisbech, Cambridgeshire.
1878. *Peek, William. St. Clair, Hayward's Heath, Sussex.
*Peel, George. Soho Iron Works, Manchester.

Year of Election.

1873. ‡Peel, Thomas. 9 Hampton-place, Bradford, Yorkshire.
1861. *Peile, George, jun. Shotley Bridge, Co. Durham.
1861. *Peiser, John. Barnfield House, 491 Oxford-street, Manchester.
1878. §§Pemberton, Charles Seaton. 44 Lincoln's Inn-fields, London, W.C.
1865. ‡Pemberton, Oliver. 18 Temple-row, Birmingham.
1861. *Pender, John, M.P. 18 Arlington-street, London, S.W.
1868. ‡Pendergast, Thomas. Lancefield, Cheltenham.
1856. §Pengelly, William, F.R.S., F.G.S. Lamorna, Torquay.
1875. ‡Percival, Rev. J., M.A., LL.D. President of Trinity College, Oxford.
1845. ‡Percy, John, M.D., F.R.S., F.G.S., Professor of Metallurgy in the Royal School of Mines. Museum of Practical Geology, Jermyn-street, S.W.; and 1 Gloucester-crescent, Hyde Park, London, W.
*Perigal, Frederick. Thatched House Club, St. James's-street, London, S.W.
1868. *Perkin, William Henry, F.R.S., F.C.S. The Chestnuts, Sudbury, Harrow.
1861. ‡*Perkins, Rev. George. St. James's View, Dickenson-road, Rusholme, near Manchester.*
1877. §§Perkins, Loftus. 140 Abbey-road, Kilburn, London, N.W.
Perkins, Rev. R. B., D.C.L. Wotton-under-Edge, Gloucestershire.
1864. *Perkins, V. R. 54 Gloucester-street, London, S.W.
1861. ‡*Perring, John Shae.* 104 *King-street, Manchester.*
Perry, The Right Rev. Charles, M.A., D.D. 32 Avenue-road, Regent's Park, London, N.W.
1879. §Perry, James. Roscommon.
1874. ‡Perry, Professor John. Scientific Club, Savile-row, London, W.
*Perry, Rev. S. G. F., M.A. Tottington Vicarage, near Bury.
1870. *Perry, Rev. S. J., F.R.S., F.R.A.S., F.M.S. Stonyhurst College Observatory, Whalley, Blackburn.
1861. *Petrie, John. South-street, Rochdale.
Peyton, Abel. Oakhurst, Edgbaston, Birmingham.
1871. *Peyton, John E. H., F.R.A.S., F.G.S. 108 Marina, St. Leonard's-on-Sea.
1867. ‡Phayre, Lieut.-General Sir Arthur, K.C.S.I., C.B., Governor of Mauritius.
1863. *Phené, John Samuel, LL.D., F.S.A., F.G.S., F.R.G.S. 5 Carlton-terrace, Oakley-street, London, S.W.
1870. ‡Philip, T. D. 51 South Castle-street, Liverpool.
1853. *Philips, Rev. Edward. Hollington, Uttoxeter, Staffordshire.
1853. *Philips, Herbert. 35 Church-street, Manchester.
*Philips, Mark. Welcombe, Stratford-on-Avon.
Philips, Robert N. The Park, Manchester.
1877. §Philips, T. Wishart. 20 New Morant Street, Poplar, London, E.
1863. ‡Philipson, Dr. 1 Savile-row, Newcastle-on-Tyne.
1859. *Phillips, Major-General Sir B. Travell. United Service Club, Pall Mall, London, S.W.
1862. ‡Phillips, Rev. George, D.D. Queen's College, Cambridge.
1872. ‡Phillips, J. Arthur. 18 Fopstone-road, Earl's Court-road, London, S.W.
1868. ‡Phipson, R. M., F.S.A. Surrey-street, Norwich.
1868. ‡Phipson, T. L., Ph.D. 4 The Cedars, Putney, Surrey, S.W.
1864. ‡Pickering, William. Oak View, Clevedon.
1861. ‡*Pickstone, William. Radcliff Bridge near Manchester.*

Year of Election.

1870. ‡Picton, J. Allanson, F.S.A. Sandyknowe, Wavertree, Liverpool.
1870. ‡Pigot, Rev. E. V. Malpas, Cheshire.
1871. ‡Pigot, Thomas F., C.E., M.R.I.A. Royal College of Science, Dublin.
*Pike, Ebenezer. Besborough, Cork.
1865. ‡Pike, L. Owen. 25 Carlton-villas, Maida-vale, London, W.
1873.§§Pike, W. H. 4 The Grove, Highgate, London, N.
1857. ‡Pilkington, Henry M., M.A., Q.C. 45 Upper Mount-street, Dublin.
1863. *Pim, Captain Bedford C. T., R.N., M.P., F.R.G.S. Leaside, Kingswood-road, Upper Norwood, London, S.E.
Pim, George, M.R.I.A. Brenanstown, Cabinteely, Co. Dublin.
Pim, Jonathan. Harold's Cross, Dublin.
1877.§§Pim, Joseph T. Greenbank, Monkstown, Co. Dublin.
Pim, William H., M.R.I.A. Monkstown, Co. Dublin.
1868. ‡Pinder, T. R. St. Andrew's, Norwich.
1876. ‡Pirie, Rev. G. Queen's College Cambridge.
1859. ‡Pirrie, William, M.D., LL.D. 238 Union-street West, Aberdeen.
1866. ‡Pitcairn, David. Dudhope House, Dundee.
1875. ‡Pitman, John. Redcliff Hill, Bristol.
1864. ‡Pitt, R. 5 Widcomb-terrace, Bath.
1872. ‡Plant, Mrs. H. W. 28 Evington-street, Leicester.
1869. §Plant, James, F.G.S. 40 West-terrace, West-street, Leicester.
1865. ‡Plant, Thomas L. Camp Hill, and 33 Union-street, Birmingham.
1842. Playfair, The Right Hon. Lyon, C.B., Ph.D., LL.D., M.P., F.R.S. L. & E., F.C.S. 68 Onslow-gardens, South Kensington, London, S.W.
1867. ‡Playfair, Lieut.-Colonel R. L., H.M. Consul, Algeria. (Messrs. King & Co., Pall Mall, London, S.W.)
1857. ‡Plunkett, Thomas. Ballybrophy House, Borris-in-Ossory, Ireland.
1861. *Pochin, Henry Davis, F.C.S. Bodnant Hall, near Conway.
1846. ‡Pole, William, Mus. Doc., F.R.S., M.I.C.E. Athenæum Club, Pall Mall, London, S.W.
*Pollexfen, Rev. John Hutton, M.A. Middleton Tyas Vicarage, Richmond, Yorkshire.
Pollock, A. 52 Upper Sackville-street, Dublin.
1862. *Polwhele, Thomas Roxburgh, M.A., F.G.S. Polwhele, Truro, Cornwall.
1854. ‡Poole, Braithwaite. Birkenhead.
1868. ‡*Pooley, Thomas A., B.Sc. South Side, Clapham Common, London, S.W.*
1868. ‡Portal, Wyndham S. Malsanger, Basingstoke.
1874. ‡Porter, Rev. J. Leslie, D.D., LL.D. College Park, Belfast.
1866. §Porter, Robert. Beeston, Nottingham.
Porter, Rev. T. H., D.D., M.R.I.A. Tullyhogue, Co. Tyrone.
1863. ‡Potter, D. M. Cramlington, near Newcastle-on-Tyne.
*Potter, Edmund, F.R.S. Camfield-place, Hatfield, Herts.
1842. Potter, Thomas. George-street, Manchester.
1863. ‡Potts, James. 26 Sandhill, Newcastle-on-Tyne.
1857. *Pounden, Captain Lonsdale, F.R.G.S. Junior United Service Club, St. James's-square, London, S.W.; and Brownswood House, Enniscorthy, Co. Wexford.
1873. *Powell, Francis S. Horton Old Hall, Yorkshire; and 1 Cambridge-square, London, W.
1875 ‡Powell, William Augustus Frederick. Norland House, Clifton, Bristol.
1857. ‡Power, Sir James, Bart. Edermine, Enniscorthy, Ireland.
1867. ‡Powrie, James. Reswallie, Forfar.
1855. *Poynter, John E. Clyde Neuck, Uddingstone, Hamilton, Scotland.

Year of Election.

1869. *Preece, William Henry. Gothic Lodge, Wimbledon Common, London, S.W.

Prest, The Venerable Archdeacon Edward. The College, Durham.

*Prestwich, Joseph, M.A., F.R.S., F.G.S., F.C.S., Professor of Geology in the University of Oxford. 34 Broad-street, Oxford; and Shoreham, near Sevenoaks.

1871. ‡Price, Astley Paston. 47 Lincoln's-Inn-Fields, London, W.C.

1856. *Price, Rev. Bartholomew, M.A., F.R.S., F.R.A.S., Sedleian Professor of Natural Philosophy in the University of Oxford. 11 St. Giles's, Oxford.

1872. ‡Price, David S., Ph.D. 26 Great George-street, Westminster, S.W.

Price, J. T. Neath Abbey, Glamorganshire.

1875. *Price, Rees. 54 Loftus-road, Shepherd's Bush, London, W.

1870. *Price, Captain W. E., M.P., F.G.S. Tibberton Court, Gloucester.

1875. *Price, William Philip. Tibberton Court, Gloucester.

1876. ‡Priestley, John. Lloyd-street, Greenheys, Manchester.

1875. ‡Prince, Thomas. 6 Marlborough-road, Bradford, Yorkshire.

1864. *Prior, R. C. A., M.D. 48 York-terrace, Regent's Park, London, N.W.

1835. *Pritchard, Andrew, F.R.S.E. 87 St. Paul's-road, Canonbury, London, N.

1846. *Pritchard, Rev. Charles, M.A., F.R.S., F.G.S., F.R.A.S., Professor of Astronomy in the University of Oxford. 8 Keble-terrace, Oxford.

1872. ‡Pritchard, Rev. W. Gee. Brignal Rectory, Barnard Castle, Co. Durham.

1876. *Pritchard, Urban, M.D., F.R.C.S. 3 George-street, Hanover-square, London, W.

1863. ‡Proctor, R. S. Summerhill-terrace, Newcastle-on-Tyne.

Proctor, Thomas. Elmsdale House, Clifton Down, Bristol.

Proctor, William. Elmhurst, Higher Erith-road, Torquay.

1858. §§Proctor, William, M.D., F.C.S. 24 Petergate, York.

1863. *Prosser, Thomas. West Boldon, Newcastle-on-Tyne.

1863. ‡Proud, Joseph. South Hetton, Newcastle-on-Tyne.

1879. *Prouse, Oswald Milton, F.G.S., F.R.G.S. Westbourne House, Shaftesbury-road, London, W.

1865. ‡Prowse, Albert P. Whitchurch Villa, Mannamead, Plymouth.

1872. *Pryor, M. Robert. Western Manor, Stevenage, Herts.

1871. *Puckle, Thomas John. Woodcote-grove, Carshalton, Surrey.

1873. ‡Pullan, Lawrence. Bridge of Allan, N.B.

1867. *Pullar, Robert. 6 St. Leonard Bank, Perth.

1842. *Pumphrey, Charles. Southfield, King's Norton, near Birmingham.

Punnet, Rev. John, M.A., F.C.P.S. St. Earth, Cornwall.

1852. ‡Purdon, Thomas Henry, M.D. Belfast.

1860. ‡Purdy, Frederick, F.S.S., Principal of the Statistical Department of the Poor Law Board, Whitehall, London. Victoria-road, Kensington, London, W.

1874. ‡Purser, Frederick, M.A. Rathmines, Dublin.

1866. ‡Purser, Professor John, M.A., M.R.I.A. Queen's College, Belfast.

1878. §§Purser, John Mallet. 3 Wilton-terrace, Dublin.

1860. *Pusey, S. E. B. Bouverie. Pusey House, Faringdon.

1868. §Pye-Smith, P. H., M.D. 56 Harley-street, W.; and Guy's Hospital, London, S.E.

1879. §Pye-Smith, R. J. 7 Surrey-street, Sheffield.

1861. *Pyne, Joseph John. St. German's Villa, St. Lawrence-road, Notting Hill, London, W.

Year of Election.

1870. ‡Rabbits, W. T. Forest Hill, London, S.E.
1860. ‡Radcliffe, Charles Bland, M.D. 25 Cavendish-square, London, W.
1870. ‡Radcliffe, D. R. Phœnix Safe Works, Windsor, Liverpool.
1877. ‡Radford, George D. Mannamead, Plymouth.
1879. §Radford, R. Heber, M.I.C.E. Wood Bank, Pitsmoor, Sheffield.
*Radford, William, M.D. Sidmount, Sidmouth.
1878. §§Rae, John, M.D. 2 Addison-gardens, Kensington, London, W.
1854. ‡Raffles, Thomas Stamford. 13 Abercromby-square, Liverpool.
1870. ‡*Raffles, William Winter. Sunnyside, Prince's Park, Liverpool.*
1864. ‡Rainey, James T. St. George's Lodge, Bath.
Rake, Joseph. Charlotte-street, Bristol.
1863. ‡Ramsay, Alexander, F.G.S. Kilmorey Lodge, 6 Kent-gardens, Ealing, W.
1845. ‡Ramsay, Andrew Crombie, LL.D., F.R.S., F.G.S., Director-General of the Geological Survey of the United Kingdom and of the Museum of Economic Geology. (President Elect.) Geological Survey Office, Jermyn-street, London, S.W.
1867. ‡*Ramsay, James, jun. Dundee.*
1861. ‡Ramsay, John, M.P. Kildalton, Argyleshire.
1867. *Ramsay, W. F., M.D. 61 Overstone-road, Hammersmith, London, W.
1876. ‡Ramsay, William, Ph.D. 11 Ashton-terrace, Glasgow.
1873. *Ramsden, William. Bracken Hall, Great Horton, Bradford, Yorkshire.
1835. *Rance, Henry (Solicitor). Cambridge.
1869. *Rance, H. W. Henniker, LL.M. 62 St. Andrew's-street, Cambridge.
1860. ‡Randall, Thomas. Grandepoint House, Oxford.
1865. ‡Randel, J. 50 Vittoria-street, Birmingham.
Ranelagh, The Right Hon. Lord. 7 New Burlington-street, Regent-street, London, W.
1868. *Ransom, Edwin, F.R.G.S. Kempstone Mill, Bedford.
1863. §Ransom, William Henry, M.D., F.R.S. The Pavement, Nottingham.
1861. ‡Ransome, Arthur, M.A. Bowdon, Manchester.
Ransome, Thomas. 34 Princess-street, Manchester.
1872. *Ranyard, Arthur Cowper, F.R.A.S. 25 Old-square, Lincoln's Inn, London, W.C.
Rashleigh, Jonathan. 3 Cumberland-terrace, Regent's Park, London, N.W.
Ratcliff, Colonel Charles, F.L.S., F.G.S., F.S.A., F.R.G.S. Wyddrington, Edgbaston, Birmingham.
1864. ‡Rate, Rev. John, M.A. Lapley Vicarage, Penkridge, Staffordshire.
1870. ‡Rathbone, Benson. Exchange-buildings, Liverpool.
1870. ‡Rathbone, Philip H. Greenbank Cottage, Wavertree, Liverpool.
1870. §§Rathbone, R. R. Beechwood House, Liverpool.
1863. ‡Rattray, W. St. Clement's Chemical Works, Aberdeen.
1874. ‡Ravenstein, E. G., F.R.G.S. 10 Lorn-road, Brixton, London, S.W.
Rawdon, William Frederick, M.D. Bootham, York.
1870. ‡Rawlins, G. W. The Hollies, Rainhall, Liverpool.
1866. *Rawlinson, Rev. Canon George, M.A., Camden Professor of Ancient History in the University of Oxford. The Oaks, Precincts, Canterbury.
1855. *Rawlinson, Major-General Sir Henry C., K.C.B., LL.D., F.R.S., F.R.G.S. 21 Charles-street, Berkeley-square, London, W.
1875. §Rawson, Sir Rawson W., K.C.M.G., C.B., F.R.G.S. Drayton House, West Drayton, Middlesex.
1868. *Rayleigh, The Right Hon. Lord, M.A., F.R.S., F.R.G.S. 4 Carlton-gardens, Pall Mall, London, S.W.; and Terling Place, Witham, Essex.

Year of Election.

1865. ‡*Rayner, Henry. West View, Liverpool-road, Chester.*
1870. ‡Rayner, Joseph (Town Clerk). Liverpool.
1852. ‡Read, Thomas, M.D. Donegal-square West, Belfast.
1865. ‡Read, William. Albion House, Epworth, Bawtry.
*Read, W. H. Rudston, M.A., F.L.S. 12 Blake-street, York.
1870. §§Reade, Thomas Mellard, C.E., F.G.S. Blundellsands, Liverpool.
1862. *Readwin, Thomas Allison, M.R.I.A., F.G.S. 28 Bold-street, Alexandra-road, Manchester.
1852. *Redfern, Professor Peter, M.D. 4 Lower-crescent, Belfast.
1863. ‡Redmayne, Giles. 20 New Bond-street, London, W.
1863. ‡Redmayne, R. R. 12 Victoria-terrace, Newcastle-on-Tyne.
Redwood, Isaac. Cae Wern, near Neath, South Wales.
1861. ‡Reed, Edward J., C.B., M.P., F.R.S. 74 Gloucester-road, South Kensington, London, W.
1875. ‡Rees-Mogg, W. Wooldridge. Cholwell House, near Bristol.
1878. §Reichel, The Ven. Archdeacon, D.D. The Archdeaconry, Trim, Ireland.
1876. ‡Reid, James. 10 Woodside-terrace, Glasgow.
1874. ‡Reid, Robert, M.A. 35 Dublin-road, Belfast.
1850. ‡Reid, William, M.D. Cruivie, Cupar, Fife.
1875. §Reinold, A. W., M.A., Professor of Physical Science. Royal Naval College, Greenwich, S.E.
1863. §Renals, E. 'Nottingham Express' Office, Nottingham.
1863. ‡Rendel, G. Benwell, Newcastle-on-Tyne.
1867. ‡Renny, W. W. 8 Douglas-terrace, Broughty Ferry, Dundee.
1871. ‡Reynolds, James Emerson, M.A., F.C.S., M.R.I.A., Professor of Chemistry in the University of Dublin. The Laboratory, Trinity College, Dublin.
1870. *Reynolds, Osborne, M.A., F.R.S., Professor of Engineering in Owens College, Manchester. Fallowfield, Manchester.
1858. §Reynolds, Richard, F.C.S. 13 Briggate, Leeds.
1858. *Rhodes, John. 18 Albion-street, Leeds.
1877. §§Rhodes, John. 358 Blackburn-road, Accrington, Lancashire.
1877. *Riccardi, Dr. Paul, Secretary of the Society of Naturalists. Via Stimmate, 15, Modena, Italy.
1868. §§Richards, Vice-Admiral Sir George H., C.B., F.R.S., F.R.G.S. The Athenæum Club, London, S.W.
1863. ‡Richardson, Benjamin Ward, M.A., M.D., F.R.S. 12 Hinde-street, Manchester-square, London, W.
1861. ‡Richardson, Charles. 10 Berkeley-square, Bristol.
1869. *Richardson, Charles. Albert Park, Abingdon, Berks.
1863. *Richardson, Edward. 6 Stanley-terrace, Gosforth, Newcastle-on-Tyne.
1868. *Richardson, George. 4 Edward-street, Werneth, Oldham.
1870. ‡Richardson, J. H. 3 Arundel-terrace, Cork.
1870. ‡Richardson, Ralph. 16 Coates-crescent, Edinburgh.
Richardson, Thomas. Montpelier-hill, Dublin.
1861. ‡Richardson, William. 4 Edward-street, Werneth, Oldham.
1876. §Richardson, William Haden. City Glass Works, Glasgow.
1861. ‡*Richson, Rev. Canon, M.A. Shakespeare-street, Ardwick, Manchester.*
1863. ‡Richter, Otto, Ph.D. 6 Derby-terrace, Glasgow
1870. ‡Rickards, Dr. 36 Upper Parliament-street, Liverpool.
1868. §Ricketts, Charles, M.D., F.G.S. 22 Argyle-street, Birkenhead.
1877. ‡Ricketts, James, M.D. St. Helen's, Lancashire.
*Riddell, Major-General Charles J. Buchanan, C.B., R.A., F.R.S. Oaklands, Chudleigh, Devon.

Year of Election.

1861. *Riddell, Henry B. Whitefield House, Rothbury, Morpeth.
1872. ‡Ridge, James. 98 Queen's-road, Brighton.
1862. ‡Ridgway, Henry Ackroyd, B.A. Bank Field, Halifax.
1861. ‡Ridley, John. 19 Belsize-park, Hampstead, London, N.W.
1863. *Rigby, Samuel. Bruche Hall, Warrington.
1873. ‡Ripley, Edward. Acacia, Apperley, near Leeds.
1873. ‡Ripley, H. W. Acacia, Apperley, near Leeds.
*Ripon, The Most Hon. the Marquis of, K.G., D.C.L., F.R.S., F.L.S., F.R.G.S. 1 Carlton-gardens, London, S.W.
1860. ‡*Ritchie, George Robert. 4 Watkyn-terrace, Coldharbour-lane, Camberwell, London, S.E.*
1867. ‡Ritchie, John. Fleuchar Craig, Dundee.
1855. ‡Ritchie, Robert, C.E. 14 Hill-street, Edinburgh.
1867. ‡Ritchie, William. Emslea, Dundee.
1869. *Rivington, John. Babbicombe, near Torquay.
1854. ‡Robberds, Rev. John, B.A. Battledown Tower, Cheltenham.
1869. *Robbins, John, F.C.S. 57 Warrington-crescent, Maida Vale, London, W.
1878. §Roberts, Charles, F.R.C.S. 2 Bolton-row, London, W.
1859. ‡Roberts, George Christopher. Hull.
1859. ‡Roberts, Henry, F.S.A. Athenæum Club, London, S.W.
1870. *Roberts, Isaac, F.G.S. Kennessee, Maghull, Lancashire.
1857. ‡Roberts, Michael, M.A. Trinity College, Dublin.
1879. §Roberts, Samuel. The Towers, Sheffield.
1879. §Roberts, Samuel, jun. The Towers, Sheffield.
1879. §Roberts, Thomas. The Knowle, Park-lane, Sheffield.
1868. §Roberts, W. Chandler, F.R.S., F.G.S., F.C.S. Royal Mint, London, E.
1866. ‡*Robertson, Alister Stuart, M.D., F.R.G.S. Horwich, Bolton, Lancashire.*
1859. ‡Robertson, Dr. Andrew. Indego, Aberdeen.
1876. ‡*Robertson, Andrew Carrick. Woodend House, Helensburgh, N.B.*
1867. §Robertson, David. Union Grove, Dundee.
1871. ‡Robertson, George, C.E., F.R.S.E. 47 Albany-street, Edinburgh.
1870. *Robertson, John. Lyme View, Whalley Range, Manchester.
1876. ‡*Robertson, R. A. 9 Queen's-square, Regent Park, Glasgow.*
1866. ‡Robertson, William Tindal, M.D. Nottingham.
1861. ‡Robinson, Enoch. Dukinfield, Ashton-under-Lyne.
1852. ‡Robinson, Rev. George. Tartaragham Glebe, Loughgall, Ireland.
1859. ‡Robinson, Hardy. 156 Union-street, Aberdeen.
*Robinson, H. Oliver. 34 Bishopsgate-street, London, E.C.
1873. §Robinson, Hugh. 82 Donegall-street, Belfast.
1861. ‡Robinson, John. Atlas Works, Manchester.
1863. ‡Robinson, J. H. Cumberland-row, Newcastle-on-Tyne.
1878.§§Robinson, John L., C.E. 198 Great Brunswick-street, Dublin.
1876. ‡Robinson, M. E. 6 Park-circus, Glasgow.
1875. *Robinson, Robert, C.E., F.G.S. 2 West-terrace, Darlington.
1860. ‡Robinson, Admiral Sir Robert Spencer, K.C.B., F.R.S. 61 Eaton-place, London, S.W.
Robinson, Rev. Thomas Romney, D.D., F.R.S., F.R.A.S., Hon. F.R.S.E., M.R.I.A., Director of the Armagh Observatory. Armagh.
1863. ‡Robinson, T. W. U. Houghton-le-Spring, Durham.
1870. ‡Robinson, William. 40 Smithdown-road, Liverpool.
1870. *Robson, E. R. 41 Parliament-street, Westminster, S.W.
1876. ‡Robson, Hazleton R. 14 Royal-crescent West, Glasgow.
1855. ‡Robson, Neil, C.E. 127 St. Vincent-street, Glasgow.

Year of Election.

1872. *Robson, William. Marchholm, Gillsland-road, Merchiston, Edinburgh.
1872. §§Rodwell, George F., F.R.A.S., F.C.S. Marlborough College, Wiltshire.
1866. ‡Roe, Thomas. Grove-villas, Sitchurch.
1860. ‡Rogers, James E. Thorold, Professor of Economic Science and Statistics in King's College, London. Beaumont-street, Oxford.
1867. ‡Rogers, James S. Rosemill, by Dundee.
1869. *Rogers, Nathaniel, M.D. 87 South-street, Exeter.
1870. ‡Rogers, T. L., M.D. Rainhill, Liverpool.
1859. ‡Rolleston, George, M.A., M.D., F.R.S., F.L.S., Professor of Anatomy and Physiology in the University of Oxford. The Park, Oxford.
1876. §Rollit, A. K., B.A., LL.D., D.C.L., F.R.A.S. Thwaite House, Cottingham, East Yorkshire.
1866. ‡Rolph, George Frederick. War Office, Horse Guards, London, S.W.
1876. ‡Romanes, George John, M.A., F.R.S., F.L.S. 18 Cornwall-terrace, Regent's Park, London, N.W.
1863. ‡*Romilly, Edward.* 14 *Hyde Park-terrace, London, W.*
1846. ‡Ronalds, Edmund, Ph.D. Stewartfield, Bonnington, Edinburgh.
1869. ‡Roper, C. H. Magdalen-street, Exeter.
1872. *Roper, Freeman Clarke Samuel, F.L.S., F.G.S. Palgrave House, Eastbourne.
1855. *Roscoe, Henry Enfield, B.A., Ph.D., LL.D., F.R.S., F.C.S., Professor of Chemistry in Owens College, Manchester.
1863. ‡Roseby, John. Haverholm House, Brigg, Lincolnshire.
1874. ‡Ross, Alexander Milton, M.A., M.D., F.G.S. Toronto, Canada.
1857. ‡Ross, David, LL.D. 32 Nelson-street, Dublin.
1872. ‡Ross, James, M.D. Tenterfield House, Waterfoot, near Manchester.
1859. *Ross, Rev. James Coulman. Baldon Vicarage, Oxford.
1874. ‡Ross, Rev. William. Chapelhill Manse, Rothesay, Scotland.
1869. *Rosse, The Right Hon. the Earl of, B.A., D.C.L., LL.D., F.R.S., F.R.A.S., M.R.I.A. Birr Castle, Parsonstown, Ireland; and 32 Lowndes-square, London, S.W.
1865. *Rothera, George Bell. 17 Waverley-street, Nottingham.
1876. ‡Rottenburgh, Paul. 13 Albion-crescent, Glasgow.
1861. ‡Routh, Edward J., M.A., F.R.S., F.R.A.S., F.G.S. St. Peter's College, Cambridge.
1872. *Row, A. V. Nursing Observatory, Daba-gardens, Vizagapatam, India. (Care of Messrs. King & Co., 45 Pall Mall, London, S.W.)
1861. ‡Rowan, David. Elliot-street, Glasgow.
1876. ‡Rowan, David. 22 Woodside-place, Glasgow.
1877. §Rowe, J. Brooking, F.L.S., F.S.A. 16 Lockyer-street, Plymouth.
1865. §Rowe, Rev. John. Load Vicarage, Langport, Somerset.
1855. *Rowney, Thomas H., Ph.D., F.C.S., Professor of Chemistry in Queen's College Galway. Salerno, Salthill, Galway.
*Rowntree, Joseph. 12 Heslington-road, York.
1862. ‡Rowsell, Rev. Evan Edward, M.A. Hambledon Rectory, Godalming.
1876. ‡Roxburgh, John. 7 Royal Bank-terrace, Glasgow.
1861. *Royle, Peter, M.D., L.R.C.P., M.R.C.S. 27 Lever-street, Manchester.
1875. ‡Rücker, A. W., M.A., Professor of Mathematics and Physics in the Yorkshire College, Leeds.

Year of Election.

1869. §Rudler, F. W., F.G.S. The Museum, Jermyn-street, London, S.W.
1873. ‡Rushforth, Joseph. 43 Ash-grove, Horton-lane, Bradford, Yorkshire.
1847. ‡Ruskin, John, M.A., F.G.S., Slade Professor of Fine Arts in the University of Oxford. Corpus Christi College, Oxford.
1857. ‡Russell, The Very Rev. C. W., D.D., M.R.I.A. Maynooth College.
1875. *Russell, The Hon. F. A. R. Pembroke Lodge, Richmond Park, Surrey.
1876. *Russell, George. 103 Blenheim-crescent, Notting Hill, London, W.
1865. ‡Russell, James, M.D. 91 Newhall-street, Birmingham.
Russell, John. 39 Mountjoy-square, Dublin.
Russell, John Scott, M.A., F.R.S.L. & E. Sydenham, S.E.; and 5 Westminster-chambers, London, S.W.
1852. *Russell, Norman Scott. 5 Westminster-chambers, London, S.W.
1876. §Russell, R., C.E., F.G.S. 1 Sea View, St. Bees, Carnforth.
1862. §Russell, W. H. L., A.B., F.R.S. 5 The Grove, Highgate, London, N.
1852. *Russell, William J., Ph.D., F.R.S., F.C.S., Professor of Chemistry in St. Bartholomew's Medical College. 34 Upper Hamilton-terrace, St. John's Wood, London, N.W.
1875. ‡Rutherford, David Greig. Surrey House, Forest Hill, London, S.E.
1871. §Rutherford, William, M.D., F.R.S., F.R.S.E., Professor of the Institutes of Medicine in the University of Edinburgh.
Rutson, William. Newby Wiske, Northallerton, Yorkshire.
1879. §Ruxton, Captain Fitzherbert, R.N. 41 Cromwell-gardens, London, S.W.
1875. ‡Ryalls, Charles Wager, LL.D. 3 Brick-court, Temple, London, E.C.
1874. §Rye, E. C., F.Z.S., Librarian R.G.S. 70 Charlewood-road, Putney, S.W.
1865. ‡Ryland, Thomas. The Redlands, Erdington, Birmingham.
1861. *Rylands, Thomas Glazebrook, F.L.S., F.G.S. Highfields, Thelwall, near Warrington.

*Sabine, General Sir Edward, K.C.B., R.A., LL.D., D.C.L., F.R.S., F.R.A.S., F.L.S., F.R.G.S. 13 Ashley-place, Westminster, S.W.
1865. ‡*Sabine, Robert. Auckland House, Willesden-lane, London, N.W.*
1871. §§Sadler, Samuel Champernowne. Purton Court, Purton, near Swindon, Wiltshire.
1866. *St. Albans, His Grace the Duke of. Bestwood Lodge, Arnold, near Nottingham.
Salkeld, Joseph. Penrith, Cumberland.
1857. ‡Salmon, Rev. George, D.D., D.C.L., F.R.S., Regius Professor of Divinity in the University of Dublin. Trinity College, Dublin.
1873. *Salomons, Sir David, Bart. Broomhill, Tunbridge Wells.
1872. ‡Salvin, Osbert, M.A., F.R.S., F.L.S. Brookland Avenue, Cambridge.
1842. Sambrooke, T. G. 32 Eaton-place, London, S.W.
1861. *Samson, Henry. 6 St. Peter's-square, Manchester.
1867. ‡*Samuelson, Edward. Roby, near Liverpool.*
1870. ‡*Samuelson, James. St. Domingo-grove, Everton, Liverpool.*
1861. *Sandeman, Archibald, M.A. Tulloch, Perth.
1876. §§Sandeman, David. Woodlands, Lenzie, Glasgow.
1878. §§Sanders, Alfred, F.L.S. 2 Clarence-place, Gravesend, Kent.
1857. ‡Sanders, Gilbert. The Hill, Monkstown, Co. Dublin.
1872. ‡Sanders, Mrs. 8 Powis-square, Brighton.
1871. ‡Sanders, William R., M.D. 11 Walker-street, Edinburgh.

Year of Election.

1872. ‡SANDERSON, J. S. BURDON, M.D., F.R.S., Professor of Physiology in University College, London. 49 Queen Anne-street, London, W.
Sandes, Thomas, A.B. Sallow Glin, Tarbert, Co. Kerry.
1864. ‡Sandford, William. 9 Springfield-place, Bath.
1854. ‡Sandon, The Right Hon. Lord, M.P. 39 Gloucester-square, London, W.
1873. ‡Sands, T. C. 24 Spring-gardens, Bradford, Yorkshire.
1865. ‡Sargant, W. L. Edmund-street, Birmingham.
1868. ‡Saunders, A., C.E. King's Lynn.
1846. ‡SAUNDERS, TRELAWNEY W. India Office, London, S.W.
1864. ‡Saunders, T. W., Recorder of Bath. 1 Priory-place, Bath.
1860. *Saunders, William. 3 Gladstone-terrace, Brighton.
1871. §Savage, W. D. Ellerslie House, Brighton.
1863. ‡*Savory, Valentine. Cleckheaton, near Leeds.*
1872. *Sawyer, George David. 55 Buckingham-place, Brighton.
1868. ‡Sawyer, John Robert. Grove-terrace, Thorpe Hamlet, Norwich.
1850. ‡*Scarth, Pillans. 2 James's-place, Leith.*
1868. §Schacht, G. F. 7 Regent's-place, Clifton, Bristol.
1879. *Schäfer, E. A., F.R.S., M.R.C.S., Assistant Professor of Physiology in University College, London. Boreham-wood, Elstree, Herts.
*Schemmann, J. C. Hamburg. (Care of Messrs. Allen Everitt & Sons, Birmingham.)
1842. Schofield, Joseph. Stubley Hall, Littleborough, Lancashire.
1874. §§Scholefield, Henry. Windsor-crescent, Newcastle-on-Tyne.
*Scholes, T. Seddon. 10 Warwick-place, Leamington.
1876. ‡Schuman, Sigismond. 7 Royal Bank-place, Glasgow.
SCHUNCK, EDWARD, F.R.S., F.C.S. Oaklands, Kersall Moor, Manchester.
1873. *SCHUSTER, ARTHUR, Ph.D., F.R.S. Sunnyside, Upper Avenue-road, Regent's Park, London, N.W.
1861. *Schwabe, Edmund Salis. Ryecroft House, Cheetham Hill, Manchester.
1847. *SCLATER, PHILIP LUTLEY, M.A., Ph.D., F.R.S., F.L.S., F.G.S., Sec. Zool. Soc. (GENERAL SECRETARY.) 11 Hanover-square, London, W.
1867. ‡SCOTT, ALEXANDER. Clydesdale Bank, Dundee.
1878. §§Scott, Arthur William. St. David's College, Lampeter.
1876. ‡Scott, Mr. Bailie. Glasgow.
1871. ‡Scott, Rev. C. G. 12 Pilrig-street, Edinburgh.
1876. ‡*Scott, D. D. Glasgow.*
1872. ‡Scott, Major-General H. Y. D., C.B., R.E., F.R.S. Sunnyside, Ealing, W.
1871. ‡*Scott, James S. T. Monkrigg, Haddingtonshire.*
1857. *SCOTT, ROBERT H., M.A., F.R.S., F.G.S., F.M.S., Secretary to the Council of the Meteorological Office. 116 Victoria-street, London, S.W.
1861. §Scott, Rev. Robert Selkirk, D.D. 16 Victoria-crescent, Dowanhill, Glasgow.
1874. ‡Scott, Rev. Robinson, D.D. Methodist College, Belfast.
1864. ‡*Scott, Wentworth Lascelles. Wolverhampton.*
1858. ‡Scott, William. Holbeck, near Leeds.
1869. §Scott, William Bower. Chudleigh, Devon.
1859. ‡Seaton, John Love. Hull.
1877. ‡*Seaton, Robert Cooper, B.A. Dulwich College, Dulwich, Surrey, S.E.*
1861. *SEELEY, HARRY GOVIER, F.R.S., F.L.S., F.G.S., F.R.G.S., F.Z.S., Professor of Geography in King's College, London. 61 Adelaide-road, South Hampstead, London, N.W.

Year of Election.

1855. ‡Seligman, H. L. 135 Buchanan-street, Glasgow.
1879. §Selim, Adolphus. 21 Mincing-lane, London, E.C.
1873. ‡Semple, R. H., M.D. 8 Torrington-square, London, W.C.
1858. *Senior, George, F.S.S. Rosehill, Dodworth, near Barnsley.
1870. *Sephton, Rev. J. 92 Huskisson-street, Liverpool.
1875. §Seville, Thomas. Elm House, Royton, near Manchester.
1873. ‡Sewell, Rev. E., M.A., F.G.S., F.R.G.S. Ilkley College, near Leeds.
1868. ‡Sewell, Philip E. Catton, Norwich.
1861. *Seymour, Henry D. 209 Piccadilly, London, W.
1853. ‡*Shackles, G. L.* 6 *Albion-street, Hull.*
*Shaen, William. 15 Upper Phillimore-gardens, Kensington, London, W.
1871. *Shand, James. Fullbrooks, Worcester Park, Surrey.
1867. §§Shanks, James. Dens Iron Works, Arbroath, N.B.
1869. *Shapter, Dr. Lewis, LL.D. The Barnfield, Exeter.
1878. §§Sharp, David. Thornhill, Dumfriesshire.
Sharp, Rev. John, B.A. Horbury, Wakefield.
1861. ‡Sharp, Samuel, F.G.S., F.S.A. Great Harrowden Hall, near Wellingborough.
*Sharp, William, M.D., F.R.S., F.G.S. Horton House, Rugby.
Sharp, Rev. William, B.A. Mareham Rectory, near Boston, Lincolnshire.
Sharpey, William, M.D., LL.D., F.R.S. L. & E. 50 Torrington-square, London, W.C.
1858. *Shaw, Bentley. Woodfield House, Huddersfield.
1854. *Shaw, Charles Wright. 3 Windsor-terrace, Douglas, Isle of Man.
1870. ‡Shaw, Duncan. Cordova, Spain,
1865. ‡Shaw, George. Cannon-street, Birmingham.
1870. ‡Shaw, John. 24 Great George-place, Liverpool.
1845. ‡Shaw, John, M.D., F.L.S., F.G.S. Hop House, Boston, Lincolnshire.
1853. ‡Shaw, Norton, M.D. St. Croix, West Indies.
1878. §§Shelford, W., C.E. Great George-street, Westminster, S.W.
1839. Shepard, John. 4 Highfield-place, Manningham, Bradford, Yorkshire.
1863. ‡Shepherd, A. B. 49 Seymour-street, Portman-square, London, W.
1870. §Shepherd, Joseph. 29 Everton-crescent, Liverpool.
Sheppard, Rev. Henry W., B.A. The Parsonage, Emsworth, Hants.
1866. ‡Shilton, Samuel Richard Parr. Sneinton House, Nottingham.
1867. ‡Shinn, William C. Her Majesty's Printing Office, near Fetter-lane, London, E.C.
1870. *Shoolbred, James N., C.E., F.G.S. 3 Westminster-chambers, London, S.W.
1875. ‡Shore, Thomas W., F.C.S. Hartley Institution, Southampton.
1861. *Sidebotham, Joseph. The Beeches, Bowdon, Cheshire.
1877. *Sidebotham, Joseph Watson. The Beeches, Bowdon, Cheshire.
1873. ‡Sidgwick, R. H. The Raikes, Skipton.
1857. ‡Sidney, Frederick John, LL.D., M.R.I.A. 19 Herbert-street, Dublin.
Sidney, M. J. F. Cowpen, Newcastle-upon-Tyne.
1873. *Siemens, Alexander. 12 Queen Anne's-gate, Westminster, S.W.
1856. *Siemens, C. William, D.C.L., F.R.S., F.C.S., M.I.C.E. 12 Queen Anne's-gate, Westminster, S.W.
1878. §§Sigerson, Professor George, M.D., F.L.S., M.R.I.A. 3 Clare-street, Dublin.
1859. ‡Sim, John. Hardgate, Aberdeen.

Year of Election.

1871. ‡Sime, James. Craigmount House, Grange, Edinburgh.
1865. ‡Simkiss, T. M. Wolverhampton.
1862. ‡Simms, James. 138 Fleet-street, London, E.C.
1874.§§Simms, William. The Linen Hall, Belfast.
1876. ‡Simon, Frederick. 24 Sutherland-gardens, London, W.
1847. ‡Simon, John, C.B., D.C.L., F.R.S., F.R.C.S., Medical Officer of the Privy Council. 40 Kensington-square, London, W.
1866. ‡Simons, George. The Park, Nottingham.
1871. *Simpson, Alexander R., M.D., Professor of Midwifery in the University of Edinburgh. 52 Queen-street, Edinburgh.
1867. ‡Simpson, G. B. Seafield, Broughty Ferry, by Dundee.
1859. ‡Simpson, John. Maykirk, Kincardineshire.
1863. ‡Simpson, J. B., F.G.S. Hedgefield House, Blaydon-on-Tyne.
1857. ‡Simpson, Maxwell, M.D., LL.D., F.R.S., F.C.S., Professor of Chemistry in Queen's College, Cork.
1876. ‡Simpson, Robert. 14 Ibrox-terrace, Glasgow.
*Simpson, Rev. Samuel. Kingston House, Chester.
Simpson, William. Bradmore House, Hammersmith, London, W.
1876. ‡Sinclair, James. Titwood Bank, Pollockshields, near Glasgow.
1874. ‡Sinclair, Thomas. Dunedin, Belfast.
1834. ‡Sinclair, Vetch, M.D. 48 Albany-street, Edinburgh.
1870. *Sinclair, W. P. 19 Devonshire-road, Prince's Park, Liverpool.
1864. *Sircar, Mahendra Lal, M.D. 51 Sankaritola, Calcutta. (Care of Messrs. S. Harraden & Co., 3 Hill's-place, Oxford-street, London, W.)
1865. ‡Sissons, William. 92 Park-street, Hull.
1870. §Sladen, Walter Percy, F.G.S., F.L.S. Exley House, near Halifax.
1873. ‡Slater, Clayton. Barnoldswick, near Leeds.
1870. ‡Slater, W. B. 42 Clifton Park-avenue, Belfast.
1842. *Slater, William. Park-lane, Higher Broughton, Manchester.
1853. ‡*Sleddon, Francis.* 2 *Kingston-terrace, Hull.*
1877.§§Sleeman, Rev. Philip, L.Th., F.R.A.S., F.R.M.S. Clifton, Bristol.
1849. ‡Sloper, George Elgar. Devizes.
1849. ‡Sloper, Samuel W. Devizes.
1860.§§Sloper, S. Elgar. Winterton, near Hythe, Southampton.
1872. ‡Smale, The Hon. Sir John, Chief Justice of Hong Kong.
1867. ‡Small, David. Gray House, Dundee.
1858. ‡Smeeton, G. H. Commercial-street, Leeds.
1876. ‡Smeiton, James. Panmure Villa, Broughty Ferry, Dundee.
1876. ‡Smeiton, John G. Panmure Villa, Broughty Ferry, Dundee.
1867. ‡Smeiton, Thomas A. 55 Cowgate, Dundee.
1876.§§Smellie, Thomas D. 213 St. Vincent-street, Glasgow.
1877. ‡Smelt, Rev. Maurice Allen, M.A., F.R.A.S. Heath Lodge, Cheltenham.
1857. ‡Smith, Aquilla, M.D., M.R.I.A. 121 Lower Baggot-street, Dublin.
1868. ‡Smith, Augustus. Northwood House, Church-road, Upper Norwood, Surrey, S.E.
1872. *Smith, Basil Woodd, F.R.A.S. Branch Hill Lodge, Hampstead Heath, London, N.W.
1874. *Smith, Benjamin Leigh. 64 Gower-street, London, W.C.
1873. ‡Smith, C. Sidney College, Cambridge.
1865. ‡Smith, David, F.R.A.S. 40 Bennett's-hill, Birmingham.
1865. ‡Smith, Frederick. The Priory, Dudley.
1866. *Smith, F. C., M.P. Bank, Nottingham.
1855. ‡Smith, George. Port Dundas, Glasgow.
1876. ‡Smith, George. Glasgow.
1855. ‡Smith, George Cruickshank. 19 St. Vincent-place, Glasgow.

Year of Election.

*Smith, Henry John Stephen, M.A., LL.D., F.R.S., F.C.S., Savilian Professor of Geometry in the University of Oxford, and Keeper of the University Museum. The Museum, Oxford.

1860. *Smith, Heywood, M.A., M.D. 2 Portugal-street, Grosvenor-square, London, W.

1876. ‡*Smith, J. Glasgow.*

1870. ‡Smith, James. 146 Bedford-street South, Liverpool.

1871. *Smith, John Alexander, M.D., F.R.S.E. 10 Palmerston-place, Edinburgh.

1876. *Smith, J. Guthrie. 173 St. Vincent-street, Glasgow.

1874. ‡Smith, John Haigh. Beech Hill, Halifax, Yorkshire.

Smith, John Peter George. Sweyney Cliff, near Coalport, Shropshire.

1871. ‡Smith, Professor J. William Robertson. Free Church College, Aberdeen.

1870. ‡Smith, H. L. Crabwall Hall, Cheshire.

*Smith, Philip, B.A. The Bays, Parkfields, Putney, S.W.

1860. *Smith, Protherce, M.D. 42 Park-street, Grosvenor-square, London, W.

1837. Smith, Richard Bryan. Villa Nova, Shrewsbury.

1847. §§Smith, Robert Angus, Ph.D., F.R.S., F.C.S. 22 Devonshire-street, Manchester.

*Smith, Robert Mackay. 4 Bellevue-crescent, Edinburgh.

1870. ‡Smith, Samuel. Bank of Liverpool, Liverpool.

1866. ‡Smith, Samuel. 33 Compton-street, Goswell-road, London, E.C.

1873. ‡Smith, Swire. Lowfield, Keighley, Yorkshire.

1867. ‡Smith, Thomas. Dundee.

1867. ‡Smith, Thomas. Poole Park Works, Dundee.

1859. ‡Smith, Thomas James, F.G.S., F.C.S. Hessle, near Hull.

1852. ‡Smith, William. Eglinton Engine Works, Glasgow.

1875. *Smith, William. Sundon House, Clifton, Bristol.

1876. §§Smith, William. 12 Woodside-place, Glasgow.

1878. §§Smithson, Joseph S. Balnagowan, Rathmines, Co. Dublin.

1874. ‡Smoothy, Frederick. Bocking, Essex.

1850. *Smyth, Charles Piazzi, F.R.S.E., F.R.A.S., Astronomer Royal for Scotland, Professor of Astronomy in the University of Edinburgh. 15 Royal-terrace, Edinburgh.

1874. ‡Smyth, Henry, C.E. Downpatrick, Ireland.

1870. ‡Smyth, Colonel H. A., R.A. Barrackpore, near Calcutta.

1878. §Smyth, Mrs. Isabella. Wigmore Lodge, Cullenswood-avenue, Dublin.

1857. *Smyth, John, jun., M.A., C.E., F.M.S. Lenaderg, Banbridge, Ireland.

1868. ‡*Smyth, Rev. J. D. Hurst.* 13 *Upper St. Giles's-street, Norwich.*

1864. ‡Smyth, Warington W., M.A., F.R.S., F.G.S., F.R.G.S., Lecturer on Mining and Mineralogy at the Royal School of Mines, and Inspector of the Mineral Property of the Crown. 5 Inverness-terrace, Bayswater, London, W.

1854. ‡Smythe, Lieut.-General W. J., R.A., F.R.S. Athenæum Club, Pall Mall, London, S.W.

1878. §§Snell, H. Saxon. 3 Greville-place, Maida Hill, London, N.W.

Soden, John. Athenæum Club, Pall Mall, London, S.W.

1879. §Sollas, W. J., M.A. 4 The Polygon, Clifton, Bristol.

*Solly, Edward, F.R.S., F.L.S., F.G.S., F.S.A. Park House, Sutton, Surrey.

Sorbey, Alfred. The Rookery, Ashford, Bakewell.

1859. *Sorby, H. Clifton, LL.D., F.R.S., Pres.G.S. Broomfield, Sheffield.

1879. *Sorby, Thomas W. 269 Western Bank, Sheffield.

Year of Election.

1865. *Southall, John Tertius. Parkfields, Ross, Herefordshire.
1859. ‡Southall, Norman. 44 Cannon-street West, London, E.C.
1856. ‡Southwood, Rev. T. A. Cheltenham College.
1863. ‡Sowerby, John. Shipcote House, Gateshead, Durham.
1863. *Spark, H. King. Starforth House, Barnard Castle.
1879. §Spence, David. Brookfield House, Freyinghall, Yorkshire.
1859. ‡*Spence, Rev. James, D.D.* 6 *Clapton-square, London, N.E.*
*Spence, Joseph. 60 Holgate Hill, York.
1869. *Spence, J. Berger. Erlington House, Manchester.
1854. §Spence, Peter, F.C.S. Erlington House, Seymour-grove, Manchester.
1861. ‡Spencer, John Frederick. 28 Great George-street, London, S.W.
1861. *Spencer, Joseph. Springbank, Old Trafford, Manchester.
1863. *Spencer, Thomas. The Grove, Ryton, Blaydon-on-Tyne, Co. Durham.
1875. ‡Spencer, W. H. Richmond Hill, Clifton, Bristol.
1871. ‡*Spicer, George. Broomfield, Halifax.*
1864. *Spicer, Henry, B.A., F.L.S., F.G.S. 14 Aberdeen Park, Highbury, London, N.
1864. §§Spicer, William R. 19 New Bridge-street, Blackfriars, London, E.C.
1864. *Spiller, John, F.C.S. 2 St. Mary's-road, Canonbury, London, N.
1878. §§Spottiswoode, George Andrew. 29 Ashley-place, London, S.W.
1846. *Spottiswoode, William, M.A., D.C.L., LL.D., Pres. R.S., F.R.A.S., F.R.G.S. (President.) 41 Grosvenor-place, London, S.W.
1864. *Spottiswoode, W. Hugh. 41 Grosvenor-place, London, S.W.
1854. *Sprague, Thomas Bond. 29 Buckingham-terrace, Edinburgh.
1853. ‡Spratt, Joseph James. West Parade, Hull.
Square, Joseph Elliot, F.G.S. 24 Portland-place, Plymouth.
1877. ‡Square, William, F.R.C.S., F.R.G.S. 4 Portland-square, Plymouth.
*Squire, Lovell. The Observatory, Falmouth.
1879. §Stacye, Rev. John. The Hospital, Shrewsbury.
1858. *Stainton, Henry T., F.R.S., F.L.S., F.G.S. Mountsfield, Lewisham, S.E.
1865. §Stanford, Edward C. C. Glenwood, Dalmuir, N.B.
1837. Staniforth, Rev. Thomas. Storrs, Windermere.
Stanley, The Very Rev. Arthur Penrhyn, D.D., F.R.S., Dean of Westminster. The Deanery, Westminster, London, S.W.
Stapleton, M. H., M.B., M.R.I.A. 1 Mountjoy-place, Dublin.
1866. ‡Starey, Thomas R. Daybrook House, Nottingham.
1876. §Starling, John Henry, F.C.S. The Avenue, Erith, Kent.
Staveley, T. K. Ripon, Yorkshire.
1873. *Stead, Charles. Saltaire, Bradford, Yorkshire.
1857. ‡Steale, William Edward, M.D. 15, Hatch-street, Dublin.
1870. ‡Stearn, C. H. 2 St. Paul's-villas, Rock Ferry, Liverpool.
1863. ‡Steele, Rev. Dr. 35 Sydney-buildings, Bath.
1873. §§Steinthal, G. A. 15 Hallfield-road, Bradford, Yorkshire.
1861. ‡Steinthal, H. M. Hollywood, Fallowfield, near Manchester.
Stenhouse, John, LL.D., F.R.S., F.C.S. 17 Rodney-street, Pentonville, London, N.
1872. ‡Stennett, Mrs. Eliza. 2 Clarendon-terrace, Brighton.
1879. *Stephenson, Henry, J.P. Endcliffe Vale, Sheffield.
1861. *Stern, S. J. Littlegrove, East Barnet, Herts.
1863. ‡Sterriker, John. Driffield, Yorkshire.
1876. ‡Steuart, Walter. City Bank, Pollockshaws, near Glasgow.
1870. *Stevens, Miss Anna Maria. Belmont, Devizes-road, Salisbury.
1861. *Stevens, Henry, F.S.A., F.R.G.S. 4 Trafalgar-square, London, W.C.

Year of Election.

1868. ‡Stevenson, Henry, F.L.S. Newmarket-road, Norwich.
1878. §§Stevenson, Rev. James, M.A. 21 Garville-avenue, Rathgar, Dublin.
1863. *Stevenson, James C., M.P., F.C.S. Westoe, South Shields.
1876. *Stewart, Alexander B. Rawcliffe Lodge, Langside, Glasgow.
1855. ‡Stewart, Balfour, M.A., LL.D., F.R.S., Professor of Natural Philosophy in Owens College, Manchester.
1864. ‡Stewart, Charles, M.A., F.L.S. St. Thomas's Hospital, London, S.E.
1856. *Stewart, Henry Hutchinson, M.D., M.R.I.A. 75 Eccles-street, Dublin.
1875. *Stewart, James, B.A. Mount Hope, Sneyd Park, near Bristol.
1847. ‡Stewart, Robert, M.D. The Asylum, Belfast.
1876. ‡Stewart, William. Violet Grove House, St. George's-road, Glasgow.
1867. ‡Stirling, Dr. D. Perth.
1868. ‡Stirling, Edward. 34 Queen's-gardens, Hyde Park, London, W.
1876. ‡Stirling, William, M.D., D.Sc. The University, Edinburgh.
1867. *Stirrup, Mark, F.G.S. 14 Atkinson-street, Deansgate, Manchester.
1865. *Stock, Joseph S. 1 Chartham-terrace, Ramsgate.
1864. §Stoddart, William Walter, F.G.S., F.C.S. Grafton Lodge, Sneyd Park, Bristol.
1854. ‡Stoess, Le Chevalier Ch. de W. (Bavarian Consul). Liverpool.
*Stokes, George Gabriel, M.A., D.C.L., LL.D., Sec. R.S., Lucasian Professor of Mathematics in the University of Cambridge. Lensfield Cottage, Cambridge.
1862. ‡Stone, Edward James, M.A., F.R.S., F.R.A.S., Director of the Radcliffe Observatory, Oxford.
1874. §§Stone, J. Harris, B.A., F.L.S., F.C.S. 11 Sheffield-gardens, Kensington, London, W.
1876. ‡Stone, Octavius C., F.R.G.S. Springfield, Nuneaton.
1859. ‡Stone, Dr. William H. 14 Dean's-yard, Westminster, S.W.
1857. ‡Stoney, Bindon B., C.E., M.R.I.A., Engineer of the Port of Dublin. 42 Wellington-road, Dublin.
1878. *Stoney, G. Gerald. 3 Palmerston Park, Dublin.
1861. *Stoney, George Johnstone, M.A., F.R.S., M.R.I.A., Secretary to the Queen's University, Ireland. 3 Palmerston Park, Dublin.
1876. §Stopes, Henry, F.G.S. East Hill, Colchester.
1854. Store, George. Prospect House, Fairfield, Liverpool.
1873. ‡Storr, William. The 'Times' Office, Printing-house-square, London, E.C.
1867. Storrar, John, M.D. Heathview, Hampstead, London, N.W.
1859. §Story, Captain James. 17 Bryanston-square, London, W.
1874. §Stott, William. Greetland, near Halifax, Yorkshire.
1871. *Strachey, Lieut.-General Richard, R.E., C.S.I., F.R.S., F.R.G.S., F.L.S., F.G.S. Stowey House, Clapham Common, London, S.W.
1876. ‡Strain, John. 143 West Regent-street, Glasgow.
1863. ‡Straker, John. Wellington House, Durham.
*Strickland, Charles. Loughglyn House, Castlerea, Ireland.
1879. §Strickland, Sir Charles W., K.C.B. Hildenley-road, Malton.
Strickland, William. French Park, Roscommon, Ireland.
1859. ‡Stronach, William, R.E. Ardmellie, Banff.
1867. ‡Stronner, D. 14 Princess-street, Dundee.
1876. *Struthers, John, M.D., Professor of Anatomy in the University of Aberdeen.
1878. §§Strype, W. G., C.E. Wicklow.
1876. *Stuart, Charles Maddock. Sudbury Hill, Harrow.

Year of Election.

1872. *Stuart, Rev. Edward A. 22 Bedford-street, Norwich.
1864. ‡Style, Sir Charles, Bart. 102 New Sydney-place, Bath.
1873.§§Style, Rev. George, M.A. Giggleswick School, Yorkshire.
1879. *Styring, Robert. 3 Hartshead, Sheffield.
1857. ‡Sullivan, William K., Ph.D., M.R.I.A. Queen's College, Cork.
1873. ‡Sutcliffe, J. W. Sprink Bank, Bradford, Yorkshire.
1873. ‡Sutcliffe, Robert. Idle, near Leeds.
1863. ‡Sutherland, Benjamin John. 10 Oxford-street, Newcastle-on-Tyne.
1862. *Sutherland, George Granville William, Duke of, K.G., F.R.S., F.R.G.S. Stafford House, London, S.W.
1863. ‡Sutton, Francis, F.C.S. Bank Plain, Norwich.
1876. ‡Swan, David, jun. Braeside, Maryhill, Glasgow.
1861. *Swan, Patrick Don S. Kirkcaldy, N.B.
1862. *Swan, William, LL.D., F.R.S.E., Professor of Natural Philosophy in the University of St. Andrews. Ardchapel, by Helensburgh, N.B.
1862. *Swann, Rev. S. Kirke, F.R.A.S. Forest Hill Lodge, Warsop, Mansfield, Nottinghamshire.
1879. §Swanwick, Frederick. Whittington, Chesterfield.
Sweetman, Walter, M.A., M.R.I.A. 4 Mountjoy-square North, Dublin.
1870. *Swinburne, Sir John, Bart. Capheaton, Newcastle-on-Tyne.
1863. ‡Swindell, J. S. E. Summerhill, Kingswinford, Dudley.
1873. *Swinglehurst, Henry. Hincaster House, near Milnthorpe.
1873.§§Sykes, Benjamin Clifford, M.D. Cleckheaton.
1847. ‡Sykes, H. P. 47 Albion-street, Hyde Park, London, W.
1862. ‡Sykes, Thomas. Cleckheaton, near Leeds.
1847. ‡Sykes, Captain W. H. F. 47 Albion-street, Hyde Park, London, W.
Sylvester, James Joseph, M.A., LL.D., F.R.S. Athenæum Club, London, S.W.
1870.§§Symes, Richard Glascott, A.B., F.G.S. Geological Survey of Ireland, 14 Hume-street, Dublin.
1856. *Symonds, Frederick, M.A., F.R.C.S. 35 Beaumont-street, Oxford.
1859. ‡Symonds, Captain Thomas Edward, R.N. 10 Adam-street, Adelphi, London, W.C.
1860. ‡Symonds, Rev. W. S., M.A., F.G.S. Pendock Rectory, Worcestershire.
1859.§§Symons, G. J., F.R.S., Sec. M.S. 62 Camden-square, London, N.W.
1855. *Symons, William, F.C.S. 26 Joy-street, Barnstaple.
Synge, Francis. Glanmore, Ashford, Co. Wicklow.
1872. ‡Synge, Major-General Millington, R.E., F.S.A., F.R.G.S. United Service Club, Pall Mall, London, S.W.

1865. ‡Tailyour, Colonel Renny, R.E. Newmanswalls, Montrose, N.B.
1877. *Tait, Lawson, F.R.C.S. 7 Great Charles-street, Birmingham.
1871. ‡Tait, Peter Guthrie, F.R.S.E., Professor of Natural Philosophy in the University of Edinburgh. George-square, Edinburgh.
1867. ‡Tait, P. M., F.R.G.S. Oriental Club, Hanover-square, London, W.
§§Talbot, William Hawkshead. Hartwood Hall, Chorley, Lancashire
1874. §Talmage, C. G., F.R.A.S. Leyton Observatory, Essex, E.
1866. ‡Tarbotton, Marrott Ogle, M.I.C.E., F.G.S. Newstead-grove, Nottingham.
1878.§§Tarpey, Hugh. Dublin.
1861. *Tarratt, Henry W. Mountfield, Grove Hill, Tunbridge Wells.
1856. ‡Tartt, William Macdonald, F.S.S. Sandford-place, Cheltenham.
1857. *Tate, Alexander, C.F. Lingwood, Whitehouse, Belfast.

Year of Election.

1863. ‡Tate, John. Alnmouth, near Alnwick, Northumberland.
1870. ‡Tate, Norman A. 7 Nivell-chambers, Fazackerley-street, Liverpool.
1858. *Tatham, George. Springfield Mount, Leeds.
1876. ‡Tatlock, Robert R. 26 Burnbank-gardens, Glasgow.
1879. §Tattershall, William Edward. 15 North Church-street, Sheffield.
1864. *Tawney, Edward B., F.G.S. Woodwardian Museum, Cambridge.
1878. *Taylor, A. Claude. Clinton House, The Park, Nottingham.
1874. ‡Taylor, Alexander O'Driscoll. 3 Upper-crescent, Belfast.
1867. ‡Taylor, Rev. Andrew. Dundee.
Taylor, Frederick. Laurel Cottage, Rainhill, near Prescot, Lancashire.
1874. ‡Taylor, G. P. Students' Chambers, Belfast.
1879. §Taylor, John. Broomhall-place, Sheffield.
*Taylor, John, F.G.S. 6 Queen-street-place, Upper Thames-street, London, E.C.
1861. *Taylor, John, jun. 6 Queen-street-place, Upper Thames-street, London, E.C.
1873. ‡Taylor, John Ellor, Ph.D., F.L.S., F.G.S. The Mount, Ipswich.
1865. ‡Taylor, Joseph. 99 Constitution-hill, Birmingham.
*Taylor, Richard, F.G.S. 6 Queen-street-place, Upper Thames-street, London, E.C.
1876. ‡Taylor, Robert. 70 Bath-street, Glasgow.
1878. §§Taylor, Robert, J.P., LL.D. Corballis, Drogheda.
1870. ‡Taylor, Thomas. Aston Rowant, Tetsworth, Oxon.
*Taylor, William Edward. Hesketh Park, Southport.
1858. ‡Teale, Thomas Pridgin, jun. 20 Park-row, Leeds.
1869. ‡Teesdale, C. S. M. Whyke House, Chichester.
1876. ‡Temperley, Ernest. Queen's College, Cambridge.
1879. §Temple, Lieutenant George T., R.N. The Nash, near Worcester.
1863. ‡Tennant, Henry. Saltwell, Newcastle-on-Tyne.
*Tennant, James, F.G.S., F.R.G.S., Professor of Mineralogy in King's College. 149 Strand, London, W.C.
1857. ‡Tennison, Edward King. Kildare-street Club House, Dublin.
1866. ‡Thackeray, J. L. Arno Vale, Nottingham.
1871. ‡Thin, James. 7 Rillbank-terrace, Edinburgh.
1871. ‡Thiselton-Dyer, W. T., M.A., B.Sc., F.L.S. 10 Gloucester-road, Kew.
1835. Thom, John. Lark-hill, Chorley, Lancashire.
1870. ‡Thom, Robert Wilson. Lark-hill, Chorley, Lancashire.
1879. *Thomas Arthur. Endcliffe House, Sheffield.
1871. ‡Thomas, Ascanius William Nevill. Chudleigh, Devon.
1875. *Thomas, Christopher James. Drayton Lodge, Redland, Bristol.
Thomas, George. Brislington, Bristol.
1875. ‡Thomas, Herbert. 2 Great George-street, Bristol.
1869. ‡Thomas, H. D. Fore-street, Exeter.
1869. ‡Thomas, J. Henwood, F.R.G.S. Custom House, London, E.C.
1875. ‡Thompson, Arthur. 12 St. Nicholas-street, Hereford.
1863. ‡Thompson, Rev. Francis. St. Giles's, Durham.
1858. *Thompson, Frederick. South-parade, Wakefield.
1859. ‡Thompson, George, jun. Pidsmedden, Aberdeen.
Thompson, Harry Stephen. Kirby Hall, Great Ouseburn, Yorkshire.
1870. ‡Thompson, Sir Henry. 35 Wimpole-street, London, W.
Thompson, Henry Stafford. Fairfield, near York.
1861. *Thompson, Joseph. Woodlands, Fulshaw, near Manchester.
1864. ‡Thompson, Rev. Joseph Hesselgrave, B.A. Cradley, near Brierley Hill.

Year of Election.

Thompson, Leonard. Sheriff-Hutton Park, Yorkshire.
1873. ‡Thompson, M. W. Guiseley, Yorkshire.
1876. *Thompson, Richard. Park-street, The Mount, York.
1874. §§Thompson, Robert. Walton, Fortwilliam Park, Belfast.
1876. §Thompson, Silvanus Phillips, B.A., D.Sc., F.R.A.S., Professor of Physics in University College, Bristol. 8 Carlton-place, Clifton, Bristol.
1878. §§Thompson, T. D. Clare Hall, Raheny, Co. Dublin.
1863. ‡Thompson, William. 11 North-terrace, Newcastle-on-Tyne.
1867. ‡Thoms, William. Magdalen-yard-road, Dundee.
1855. ‡Thomson, Allen, M.D., LL.D., F.R.S. L. & E. 66 Palace Gardens-terrace, Kensington, London, W.
1850. ‡Thomson, Sir Charles Wyville. LL.D., F.R.S. L. & E., F.G.S., Regius Professor of Natural History in the University of Edinburgh. 20 Palmerston-place, Edinburgh.
1852. ‡*Thomson, Gordon A. Bedeque House, Belfast.*
Thomson, Guy. Oxford.
1850. *Thomson, Professor James, M.A., LL.D., C.E., F.R.S. L. & E. Oakfield House, University Avenue, Glasgow.
1855. ‡*Thompson, James. 82 West Nile-street, Glasgow.*
1868. §Thomson, James, F.G.S. 3 Abbotsford-place, Glasgow.
*Thomson, James Gibson. 14 York-place, Edinburgh.
1876. ‡Thomson, James R. Dalmuir House, Dalmuir, Glasgow.
1874. ‡Thomson, John. Harbour Office, Belfast.
1871. *Thomson, John Millar, F.C.S. King's College, London, W.C.
1871. ‡Thomson, Robert, LL.B. 12 Rutland-square, Edinburgh.
1865. ‡Thomson, R. W., C.E., F.R.S.E. 3 Moray-place, Edinburgh.
1847. *Thomson, Sir William, M.A., LL.D., D.C.L., F.R.S. L. & E., Professor of Natural Philosophy in the University of Glasgow, The University, Glasgow.
1877. *Thomson, Lady. The University, Glasgow.
1874. §Thomson, William, F.R.S.E., F.C.S. Royal Institution, Manchester.
1876. ‡Thomson, William. 6 Mansfield-place, Edinburgh.
1871. ‡*Thomson, William Burnes, F.R.S.E. 1 Ramsay-gardens, Edinburgh.*
1871. ‡Thornburn, Rev. David, M.A. 1 John's-place, Leith.
1852. ‡Thornburn, Rev. William Reid, M.A. Starkies, Bury, Lancashire.
*Thornton, Samuel, J.P. Oakfield, Moseley, near Birmingham.
1867. ‡Thornton, Thomas. Dundee.
1845. ‡Thorp, Dr. Disney. Lyppiatt Lodge, Suffolk Lawn, Cheltenham.
1871. ‡Thorp, Henry. Briarleigh, Sale, near Manchester.
1864. *Thorp, William, B.Sc., F.C.S. 39 Sandringham-road, Kingsland, London, E.
1871. ‡Thorpe, T. E., Ph.D., F.R.S. L. & E., F.C.S., Professor of Chemistry in Yorkshire College, Leeds.
1868. ‡Thuillier, Lieut.-General Sir H. E. L., R.A., C.S.I., F.R.S., F.R.G.S. South Bank Lodge, Stratford-road, Kensington, London, W.
1870. ‡Tichborne, Charles R. C., LL.D., F.C.S., M.R.I.A. Apothecaries' Hall of Ireland, Dublin.
1873. *Tiddeman, R. H., M.A., F.G.S. 28 Jermyn-street, London, S.W.
1874. ‡Tilden, William A., D.Sc., F.C.S. Clifton College, Bristol.
1873. ‡Tilghman, B. C. Philadelphia, United States.
1865. ‡Timmins, Samuel, J.P., F.S.A. Elvetham-road, Edgbaston, Birmingham.
Tinker, Ebenezer. Mealhill, near Huddersfield.
*Tinne, John A., F.R.G.S. Briarley, Aigburth, Liverpool.
1876. ‡Todd, Rev. Dr. Tudor Hall, Forest Hill, London, S.E.

Year of Election.

1861. *Todhunter, Isaac, M.A., F.R.S., Principal Mathematical Lecturer at St. John's College, Cambridge. Brookside, Cambridge.
1857. ‡Tombe, Rev. Canon. Glenealy, Co. Wicklow.
1856. ‡Tomes, Robert Fisher. Welford, Stratford-on-Avon.
1864. *Tomlinson, Charles, F.R.S., F.C.S. 3 Ridgmount-terrace, Highgate, London, N.
1863. ‡*Tone, John F. Jesmond-villas, Newcastle-on-Tyne.*
1865. §§Tonks, Edmund, B.C.L. Packwood Grange, Knowle, Warwickshire.
1865. ‡Tonks, William Henry. The Rookery, Sutton Coldfield.
1873. *Tookey, Charles, F.C.S. Royal School of Mines, Jermyn-street, London, S.W.
1861. *Topham, John, M.I.C.E. High Elms, 265 Mare-street, Hackney, London, E.
1872. *Topley, William, F.G.S., A.I.C.E. Geological Survey Office, Jermyn-street, London, S.W.
1875. §Torr, Charles Hawley. Harrowby House, Park-row, Nottingham.
1863. ‡Torrens, Colonel Sir R. R., K.C.M.G. 2 Gloucester-place, Hyde Park, London, W.
1859. ‡Torry, Very Rev. John, Dean of St. Andrews. Coupar Angus, N.B.
Towgood, Edward. St. Neot's, Huntingdonshire.
1873. ‡Townend, W. H. Heaton Hall, Bradford, Yorkshire.
1875. ‡Townsend, Charles. Avenue House, Cotham Park, Bristol.
1857. *Townsend, Rev. Richard, M.A., F.R.S., Professor of Natural Philosophy in the University of Dublin. Trinity College, Dublin.
1861. ‡Townsend, William. Attleborough Hall, near Nuneaton.
1854. ‡Towson, John Thomas, F.R.G.S. 47 Upper Parliament-street, Liverpool; and Local Marine Board, Liverpool.
1877. §Tozer, Henry. Ashburton.
1876. *Trail, J. W. H., M.A., M.B., F.L.S. King's College, Old Aberdeen.
1870. ‡Traill, William A., M.R.I.A. Geological Survey of Ireland, 14 Hume-street, Dublin.
1875. ‡Trapnell, Caleb. Severnleigh, Stoke Bishop.
1868. ‡Traquair, Ramsay H., M.D., Professor of Zoology. Museum of Science and Art, Edinburgh.
1835. Travers, Robert, M.B. Williamstown, Blackrock, Co. Dublin.
1865. ‡Travers, William, F.R.C.S. 1 Bath-place, Kensington, London, W.
Tregelles, Nathaniel. Liskeard, Cornwall.
1868. ‡Trehane, John. Exe View Lawn, Exeter.
1869. ‡Trehane, John, jun. Bedford-circus, Exeter.
1870. ‡Trench, Dr. Municipal Offices, Dale-street, Liverpool.
Trench, F. A. Newlands House, Clondalkin, Ireland.
1871. ‡Tribe, Alfred, F.C.S. 14 Denbigh-road, Bayswater, London, W.
1879. §Trickett, F. W. 12 Old Haymarket, Sheffield.
1877. ‡Trimen, Henry, M.B., F.L.S. British Museum, London, W.C.
1871. ‡Trimen, Rowland, F.L.S., F.Z.S. Colonial Secretary's Office, Cape Town, Cape of Good Hope.
1860. §Tristram, Rev. Henry Baker, M.A., LL.D., F.R.S., F.L.S., Canon of Durham. The College, Durham.
1869. ‡Troyte, C. A. W. Huntsham Court, Bampton, Devon.
1864. ‡*Truell, Robert. Ballyhenry, Ashford, Co. Wicklow.*
1869. ‡Tucker, Charles. Marlands, Exeter.
1847. *Tuckett, Francis Fox. 10 Baldwin-street, Bristol.
Tuke, James H. Bank, Hitchen.
1871. ‡Tuke, J. Batty, M.D. Cupar, Fifeshire.

Year of Election.

1867. ‡Tulloch, The Very Rev. Principal, D.D. St. Andrew's, Fifeshire.
1854. ‡Turnbull, James, M.D. 86 Rodney-street, Liverpool.
1855. §§Turnbull, John. 37 West George-street, Glasgow.
1856. ‡Turnbull, Rev. J. C. 8 Bays-hill-villas, Cheltenham.
1871. §Turnbull, William, F.R.S.E. 14 Lansdowne-crescent, Edinburgh.
1873. *Turner, George. Horton Grange, Bradford, Yorkshire.
Turner, Thomas, M.D. 31 *Curzon-street, Mayfair, London, W.*
1875. ‡Turner, Thomas, F.S.S. Ashley House, Kingsdown, Bristol.
1863. *Turner, William, M.B., F.R.S. L. & E., Professor of Anatomy in the University of Edinburgh. 16 Eton-terrace, Edinburgh.
1842. Twamley, Charles, F.G.S. Ryton-on-Dunsmore, Coventry.
1847. ‡Twiss, Sir Travers, Q.C., D.C.L., F.R.S., F.R.G.S. 3 Paper-buildings, Temple, London, E.C.
1865. ‡Tylor, Edward Burnett, D.C.L., F.R.S. Linden, Wellington, Somerset.
1858. *Tyndall, John, D.C.L., LL.D., Ph.D., F.R.S., F.G.S., Professor of Natural Philosophy in the Royal Institution. Royal Institution, Albemarle-street, London, W.
1861. *Tysoe, John. 28 Seedley-road, Pendleton, near Manchester.

1876. *Unwin, W. C., A.I.C.E., Professor of Hydraulic Engineering. Cooper's Hill, Middlesex.
1872. ‡Upward, Alfred. 11 Great Queen-street, Westminster, London, S.W.
1876. ‡Ure, John F. 6 Claremont-terrace, Glasgow.
1859. ‡Urquhart, W. Pollard. Craigston Castle, N.B.; and Castlepollard, Ireland.
1866. ‡Urquhart, William W. Rosebay, Broughty Ferry, by Dundee.

*Vance, Rev. Robert. 24 Blackhall-street, Dublin.
1863. ‡Vandoni, le Commandeur Comte de, Chargé d'Affaires de S. M. Tunisienne, Geneva.
1854. ‡Varley, Cromwell F., F.R.S. Cromwell House, Bexley Heath, Kent.
1868. ‡Varley, Frederick H., F.R.A.S. Mildmay Park Works, Mildmay-avenue, Stoke Newington, London, N.
1865. *Varley, S. Alfred. Hatfield, Herts.
1870. ‡Varley, Mrs. S. A. Hatfield, Herts.
1869. ‡Varwell, P. Alphington-street, Exeter.
1875. ‡Vaughan, Miss. Burlton Hall, Shrewsbury.
1849. *Vaux, Frederick. Central Telegraph Office, Adelaide, South Australia.
1873. *Verney, Captain Edmund H., R.N., F.R.G.S. Rhianva, Bangor, North Wales.
Verney, Sir Harry, Bart. Lower Claydon, Buckinghamshire.
1866. ‡Vernon, Rev. E. H. Harcourt. Cotgrave Rectory, near Nottingham.
Vernon, George John, Lord. 32 Curzon-street, London, W.; and Sudbury Hall, Derbyshire.
1854. *Vernon, George V., F.R.A.S. 1 Osborne-place, Old Trafford, Manchester.
1879. §Veth, D. D. Leiden, Holland.
1864. *Vicary, William, F.G.S. The Priory, Colleton-crescent, Exeter.
1868. ‡Vincent, Rev. William. Postwick Rectory, near Norwich.
1875. ‡Vines, David, F.R.A.S. Observatory House, Somerset-street, Kingsdown, Bristol.
1856. ‡Vivian, Edward, M.A. Woodfield, Torquay.
*Vivian, H. Hussey, M.P., F.G.S. Park Werne, Swansea; and 27 Belgrave-square, London, S.W.

Year of Election.

1856. §§ VOELCKER, J. CH. AUGUSTUS, Ph.D., F.R.S., F.C.S., Professor of Chemistry to the Royal Agricultural Society of England. 39 Argyll-road, Kensington, London, W.
1875. ‡ Volckman, Mrs. E. G. 43 Victoria-road, Kensington, London, W.
1875. ‡ Volckman, William. 43 Victoria-road, Kensington, London, W.
‡ Vose, Dr. James. Gambier-terrace, Liverpool.

1875. ‡ *Wace, Rev. A. St. Paul's, Maidstone, Kent.*
1860. §§ Waddingham, John. Guiting Grange, Winchcombe, Gloucestershire.
1859. ‡ *Waddington, John. New Dock Works, Leeds.*
1879. * Wake, Bernard. Abbeyfield, Sheffield.
1870. § WAKE, CHARLES STANILAND. 70 Wright-street, Hull.
1855. * Waldegrave, The Hon. Granville. 26 Portland-place, London, W.
1873. ‡ Wales, James. 4 Mount Royd, Manningham, Bradford, Yorkshire.
1869. * Walford, Cornelius. 86 Belsize Park-gardens, London, N.W.
1849. § WALKER, CHARLES V., F.R.S., F.R.A.S. Fernside, Reigate Hill, Reigate.
Walker, Sir Edward S. Berry Hill, Mansfield.
Walker, Frederick John. The Priory, Bathwick, Bath.
1866. ‡ Walker, H. Westwood, Newport, by Dundee.
1855. ‡ Walker, John. 1 Exchange-court, Glasgow.
1842. * Walker, John. Thorncliffe, Kenilworth-road, Leamington.
1866. * WALKER, J. F., M.A., F.C.P.S., F.C.S., F.G.S., F.L.S. 16 Gillygate, York.
1867. * Walker, Peter G. 2 Airlie-place, Dundee.
1866 ‡ Walker, S. D. 38 Hampden-street, Nottingham.
1869. * Walker, Thomas F. W., M.A., F.G.S., F.R.G.S. 3 Circus, Bath.
Walker, William. 47 Northumberland-street, Edinburgh.
1869. ‡ *Walkey, J. E. C. High-street, Exeter.*
1863. ‡ WALLACE, ALFRED RUSSEL, F.R.G.S., F.L.S. Waldron Edge, Duppas Hill, Croydon.
1859. ‡ WALLACE, WILLIAM, Ph.D., F.C.S. Chemical Laboratory, 138 Bath-street, Glasgow.
1857. ‡ Waller, Edward. Lisenderry, Aughnacloy, Ireland.
1862. ‡ *Wallich, George Charles, M.D., F.R.G.S., F.L.S. Terrace House, St. George's-terrace, Herne Bay.*
1862. ‡ WALPOLE, The Right Hon. SPENCER HORATIO, M.A., D.C.L., M.P., F.R.S. Ealing, London, W.
1857. ‡ Walsh, Albert Jasper, F.R.C.S.I. 89 Harcourt-street, Dublin.
Walsh, John (Prussian Consul). Dundrum Castle, Co. Dublin.
1863. ‡ Walters, Robert. Eldon-square, Newcastle-on-Tyne.
Walton, Thomas Todd. Mortimer House, Clifton, Bristol.
1863. ‡ Wanklyn, James Alfred. 7 Westminster-chambers, London, S.W.
1872. ‡ Warburton, Benjamin. Leicester.
1874. § Ward, F. D. Fernleigh, Botanic-road, Belfast.
1879. § Ward, H. Marshall. Christ's College, Cambridge.
1874. § Ward, John, F.R.G.S. Lenox Vale, Belfast.
1857. ‡ Ward, John S. Prospect Hill, Lisburn, Ireland.
Ward, Rev. Richard, M.A. 12 *Eaton-place, London, S.W.*
1863. ‡ Ward, Robert. Dean-street, Newcastle-on-Tyne.
* Ward, William Sykes, F.C.S. 12 Bank-street, and Denison Hall, Leeds.
1867. ‡ Warden, Alexander J. Dundee.
1858. ‡ Wardle, Thomas. Leek Brook, Leek, Staffordshire.
1865. ‡ Waring, Edward John, M.D., F.L.S. 49 Clifton-gardens, Maida Vale, London, W.

Year of Election.

1878. §Warington, Robert. Harpenden, St. Alban's, Herts.
1872. *Warner, Thomas. 47 Sussex-square, Brighton.
1856. ‡Warner, Thomas H. Lee. Tiberton Court, Hereford.
1875. ‡Warren, Algernon. Naseby House, Pembroke-road, Clifton, Bristol.
1865. *Warren, Edward P. 13 Old-square, Birmingham.
Warwick, William Atkinson. Wyddrington House, Cheltenham.
1856. ‡Washbourne, Buchanan, M.D. Gloucester.
1876. ‡Waterhouse, A. Willenhall House, Barnet, Herts.
*Waterhouse, John, F.R.S., F.G.S., F.R.A.S. Wellhead, Halifax, Yorkshire.
1875. *Waterhouse, Major J. Surveyor-General's Office, Calcutta. (Care of Messrs. Trübner & Co., Ludgate-hill, London, E.C.)
1854. ‡Waterhouse, Nicholas. 5 Rake-lane, Liverpool.
1870. ‡Waters, A. T. H., M.D. 29 Hope-street, Liverpool.
1875. §Waters, Arthur W., F.G.S., F.L.S. Woodbrook, Alderley Edge, near Manchester.
1875. ‡Watherston, Alexander Law, M.A., F.R.A.S. Bowdon, Cheshire.
1867. ‡Watson, Rev. Archibald, D.D. The Manse, Dundee.
1855. ‡Watson, Ebenezer. 16 Abercromby-place, Glasgow.
1867. ‡Watson, Frederick Edwin. Thickthorne House, Cringleford, Norwich.
*Watson, Henry Hough, F.C.S. 227 The Folds, Bolton-le-Moors.
Watson, Hewett Cottrell. Thames Ditton, Surrey.
1873. *Watson, Sir James. Milton-Lockhart, Carluke, N.B.
1859. ‡Watson, John Forbes, M.A., M.D., F.L.S. India Museum, London, S.W.
1863. ‡Watson, Joseph. Bensham-grove, near Gateshead-on-Tyne.
1863. ‡Watson, R. S. 101 Pilgrim-street, Newcastle-on-Tyne.
1867. ‡Watson, Thomas Donald. 41 Cross-street, Finsbury, London, E.C.
1879. §Watson, William Henry, F.C.S. Braystones, near Whitehaven, Cumberland.
1869. ‡Watt, Robert B. E., C.E., F.R.G.S. Ashley-avenue, Belfast.
1861. ‡Watts, Sir James. Abney Hall, Cheadle, near Manchester.
1875. *Watts, John, B.A., D.Sc. 57 Baker-street, Portman-square, London, W.
1846. §§Watts, John King, F.R.G.S. Market-place, St. Ives, Hunts.
1870. §Watts, William, F.G.S. Oldham Corporation Waterworks, Piethorn, near Rochdale.
1873. *Watts, W. Marshall, D.Sc. Giggleswick Grammar School, near Settle.
Waud, Major E. Manston Hall, near Leeds.
Waud, Rev. S. W., M.A., F.R.A.S., F.C.P.S. Rettenden, near Wickford, Essex.
1859. ‡Waugh, Edwin. Sager-street, Manchester.
1859. *Waveney, The Right Hon. Lord, F.R.S. 7 Audley-square, London, W.
*Way, J. Thomas, F.C.S. 9 Russell-road, Kensington, London, S.W.
1869. ‡Way, Samuel James. Adelaide, South Australia.
1871. ‡Webb, Richard M. 72 Grand-parade, Brighton.
*Webb, Rev. Thomas William, M.A., F.R.A.S. Hardwick Vicarage, Hay, South Wales.
1866. *Webb, William Frederick, F.G.S., F.R.G.S. Newstead Abbey, near Nottingham.
1859. ‡Webster, John. 42 King-street, Aberdeen.
1834. ‡Webster, Richard, F.R.A.S. 6 Queen Victoria-street, London, E.C.
1845. ‡*Wedgewood, Hensleigh. 17 Cumberland-terrace, Regent's Park, London, N.W.*

Year of Election.

1854. ‡Weightman, William Henry. Farn Lea, Seaforth, Liverpool.
1865. ‡Welch, Christopher, M.A. University Club, Pall Mall East, London, S.W.
1867. §Weldon, Walter, F.R.S.E. Rede Hall, Burstow, near Crawley, Surrey.
1878. §Weldon, Mrs. Walter. Rede Hall, Burstow, near Crawley, Surrey.
1879. §Weldon, W. A. D. Rede Hall, Burstow, near Crawley, Surrey.
1876. §Weldon, W. F. R. Abbey Lodge, Merton, Surrey.
1879. §Wells, Charles A. Etna Iron Works, Lewes.
1850. ‡Wemyss, Alexander Watson, M.D. St. Andrews, N.B.
Wentworth, Frederick W. T. Vernon. Wentworth Castle, near Barnsley, Yorkshire.
1864. *Were, Anthony Berwick. Whitehaven, Cumberland.
1865. ‡Wesley, William Henry. Royal Astronomical Society, Burlington House, London, W.
1853. ‡West, Alfred. Holderness-road, Hull.
1870. ‡West, Captain E. W. Bombay.
1853. ‡West, Leonard. Summergangs Cottage, Hull.
1853. ‡West, Stephen. Hessle Grange, near Hull.
1851. *Western, Sir T. B., Bart. Felix Hall, Kelvedon, Essex.
1870. §Westgarth, William. 10 Bolton-gardens, South Kensington, London, W.
1842. Westhead, Edward. Chorlton-on-Medlock, near Manchester.
Westhead, John. Manchester.
1857. *Westley, William. 24 Regent-street, London, S.W.
1863. ‡Westmacott, Percy Whickham, Gateshead, Durham.
1860. ‡Weston, James Woods. Belmont House, Pendleton, Manchester.
1875. *Weston, Joseph D. Dorset House, Clifton Down, Bristol.
1864. ‡Westropp, W. H. S., M.R.I.A. Lisdoonvarna, Co. Clare.
1860. ‡Westwood, John O., M.A., F.L.S., Professor of Zoology in the University of Oxford. Oxford.
1853. ‡Wheatley, E. B. Cote Wall, Mirfield, Yorkshire.
1866. ‡Wheatstone, Charles C. 19 Park-crescent, Regent's Park, London, N.W.
1847. ‡Wheeler, Edmund, F.R.A.S. 48 Tollington-road, Holloway, London, N.
1878. *Wheeler, W. H., C.E. Churchyard, Boston, Lincolnshire.
1879. *Whidborne, George Ferris, M.A., F.G.S. Charante, Torquay.
1873. ‡Whipple, George Matthew, B.Sc., F.R.A.S. Kew Observatory, Richmond, Surrey.
1874. §Whitaker, Henry, M.D. 33 High-street, Belfast.
1859. *Whitaker, William, B.A., F.G.S. Geological Survey Office, 28 Jermyn-street, London, S.W.
1876. ‡White, Angus. Easdale, Argyleshire.
1864. ‡White, Edmund. Victoria Villa, Batheaston, Bath.
1837. ‡White, James, F.G.S. 8 Thurloe-square, South Kensington, London, S.W.
1876. *White, James. Overtoun, Dumbarton.
1873. §§White, John. Medina Docks, Cowes, Isle of Wight.
White, John. 80 Wilson-street, Glasgow.
1859. ‡White, John Forbes. 16 Bon Accord-square, Aberdeen.
1865. ‡White, Joseph. Regent's-street, Nottingham.
1869. ‡White, Laban. Blanford, Dorset.
1859. ‡White, Thomas Henry. Tandragee, Ireland.
1877. *White, William. 365 Euston-road, London, N.W.
1861. ‡Whitehead, James, M.D. 87 Mosley-street, Manchester.
1858. ‡Whitehead, J. H. Southsyde, Saddleworth.

Year of Election.

1861. *Whitehead, John B. Ashday Lea, Rawtenstall, Manchester.
1861. *Whitehead, Peter Ormerod, C.E. Drood House, Old Trafford, Manchester.
1855. **Whitehouse, Wildeman, W. O.* 12 *Thurlow-road, Hampstead, London, N.W.*
Whitehouse, William. 10 Queen's-street, Rhyl.
1871. ‡Whitelaw, Alexander. 1 Oakley-terrace, Glasgow.
1866. ‡Whitfield, Samuel. Eversfield, Eastnor-grove, Leamington.
1874. ‡Whitford, William. 5 Claremont-street, Belfast.
1852. ‡Whitla, Valentine. Beneden, Belfast.
Whitley, Rev. Charles Thomas, M.A., F.R.A.S. Bedlington, Morpeth.
1870. §Whittem, James Sibley. Walgrave, near Coventry.
1857. *Whitty, Rev. John Irwine, M.A., D.C.L., LL.D. 94 Baggot-street, Dublin.
1874. *Whitwell, Mark. Redland House, Bristol.
*Whitworth, Sir Joseph, Bart., LL.D., D.C.L., F.R.S. The Firs, Manchester; and Stancliffe Hall, Derbyshire.
1870. ‡Whitworth, Rev. W. Allen, M.A. 185 Islington, Liverpool.
1865. ‡Wiggin, Henry. Metchley Grange, Harborne, Birmingham.
1878.§§Wigham, John R. Albany House, Monkstown, Dublin.
1855. ‡Wilkie, John. Westburn, Helensburgh, N.B.
1857. ‡Wilkinson, George. Temple Hill, Killiney, Co. Dublin.
1879. §Wilkinson, Joseph, F.R.G.S. York.
1859. §Wilkinson, Robert. Lincoln Lodge, Totteridge, Hertfordshire.
1872. ‡Wilkinson, William. 168 North-street, Brighton.
1869. §Wilks, George Augustus Frederick, M.D. Stanbury, Torquay.
*Willert, Alderman Paul Ferdinand. Town Hall, Manchester.
1859. ‡Willet, John, C.E. 35 Albyn-place, Aberdeen.
1872. ‡Willett, Henry, F.G.S. Arnold House, Brighton.
1870. ‡*William, G. F. Copely Mount, Springfield, Liverpool.*
Williams, Charles James, B., M.D., F.R.S. 47 Upper Brook-street, Grosvenor-square, London, W.
1861. *Williams, Charles Theodore, M.A., M.B. 47 Upper Brook-street, Grosvenor-square, London, W.
1861. *Williams, Harry Samuel, M.A. 28 John-street, Bedford-row, London, W.C.
1875. *Williams, Herbert A., M.A. 91 Pembroke-road, Clifton, Bristol.
1857. ‡Williams, Rev. James. Llanfairinghornwy, Holyhead.
1870. §Williams, John, F.C.S. 14 Buckingham-street, London, W.C.
1875. *Williams, M. B. North Hill, Swansea.
1879. §Williams, Matthew W., F.C.S. 18 Kempsford-gardens, Earl's Court, London, S.W.
Williams, Robert, M.A. Bridehead, Dorset.
1869. ‡Williams, Rev. Stephen. Stonyhurst College, Whalley, Blackburn.
1877. *Williams, W. Carleton, F.C.S. Owens College, Manchester.
1865. ‡Williams, W. M. Belmont-road, Twickenham, near London.
1850. *Williamson, Alexander William, Ph.D., LL.D., For. Sec. R.S., F.C.S., Corresponding Member of the French Academy, Professor of Chemistry, and of Practical Chemistry, University College, London. (General Treasurer.) University College, London, W.C.
1857. ‡Williamson, Benjamin, M.A., F.R.S. Trinity College, Dublin.
1876. ‡Williamson, Rev. F. J. Ballantrae, Girvan, N.B.
1863. ‡Williamson, John. South Shields.
1876. ‡Williamson, Stephen. 19 James-street, Liverpool.

Year of Election

WILLIAMSON, WILLIAM C., F.R.S., Professor of Natural History in Owens College, Manchester. 4 Egerton-road, Fallowfield, Manchester.

1865. *Willmott, Henry. Hatherley Lawn, Cheltenham.

1857. ‡*Willock, Rev. W. N., D.D. Cleenish, Enniskillen, Ireland.*

1859. *Wills, Alfred, Q.C. 12 King's Bench-walk, Inner Temple, E.C.

1865. ‡Wills, Arthur W. Edgbaston, Birmingham.

WILLS, W. R. Edgbaston, Birmingham.

1878. §§Wilson, Alexander S., M.A., B.Sc. 124 Bothwell-street, Glasgow.

1859. §§Wilson, Alexander Stephen, C.E. North Kinmundy, Summerhill, by Aberdeen.

1876. ‡Wilson, Dr. Andrew. 118 Gilmore-place, Edinburgh.

1674. §§WILSON, Major C. W., C.B., R.E., F.R.S., F.R.G.S., Director of the Topographical and Statistical Department of the War Office. Ordnance Survey Office, Dublin.

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